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Library of the Museum

OF

COMPARATIVE ZOÖLOGY,

AT HARVARD COLLEGE, CAMBRIDGE, MASS.

The gift of the Manchester Geological Society

No. 5846

Nov. 26, 1892 – Mar. 25, 1895

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TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME TWENTY-SECOND.

PARTS I.—XXI.

MANCHESTER:
SOLD AT THE ROOMS OF THE SOCIETY,
36, GEORGE STREET, MANCHESTER.
C MDCCCXCV.

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*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

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CONTENTS OF VOL. XXII.

	PAGE.
Annual Meeting	1
Report of the Council for Session 1891-92	1
Treasurer's Balance Sheet	7
List of Papers, &c., read during the Session	8
New Ordinary Members	10
New Life Members	10
Members Deceased	10
Members Resigned	10
Members removed from the List	10
Election of Officers	11
New Members	14
The Ordnance Survey of Great Britain and the Geological Survey of the United States	14
Appendix to the Report:—	
Presentations to the Library, 1891-92	18
Books Purchased, 1891-92	26
Societies with which the Society exchanges its transactions, and Institutions and Journals to which a copy is sent free	26
Past Presidents of the Society	32
List of Members	33
Ordinary Meeting, November, 1892	45
New Members	45
Illness of the President	45
The Time of Meeting	46
The Glacial Drifts. Mr. C. E. De Rance, F.G.S.	49
Discovery of a large Boulder at Ardwick	53
Mr. R. Zeiller on the Fossil Plants of the Dover Coal	55
Paper. Mr. Mark Stirrup, F.G.S. Report of the Delegate to the Meeting of the British Association at Edinburgh, August, 1892	59
Globular Concretions from the Coal Measures of Lancashire	66

Digitized by Google

PAGE

Appendix.—The Glacialists' Association 69
Underground Water Committee 71
Ordinary Meeting, December, 1892 73
New Members 73
The Late President 73
Reply to Discussion on a Typical Section of the "Main" Coal of the Moira Division of the Leicestershire Coalfield 74
Discussion 78
Paper. Mr. C. E. De Rance, Assoc.Inst.C.E., &c. On the Relation of Geology to the Population and Agriculture of England and Wales 85
Discussion 110
Paper. Mr. James Grundy, H.M.I.M. How and What to Observe about Mines, with some Practical Tests.. .. 113
Discussion 138
Ordinary Meeting, Wigan, January, 1893 139
Additions to the Library 139
The Collection of Fossils.. 142
New Member 145
Paper. Mr. Isaiah Johnson. On the Substitution of Steel and Iron for Timber in Mines 145
Discussion 147
A Patent Miner's Safety Lamp, Lighted by Electricity .. 150
Paper. Mr. Henry Hall, H.M.I.M. On Mis-Shots in Mines 151
Discussion 153
Extra Meeting, Owen's College, January, 1893 159
Paper. Professor Boyd Dawkins, F.R.S. On the Coalfields of New South Wales 160
Discussion.. 169
Ordinary Meeting, February, 1893 179
New Members 179
A Proposed "Maskell Peace" Memorial 180
Map of River Basins 180
Discussion on Mr. De Rance's Paper 181
Section of Strata sunk through in No. 2 Shaft, Deaf Hill Colliery, Co: Durham 191
Discussion 195

Digitized by Google

PAGE

Paper. Professor Edward Hull, M.A., LL.D., F.R.S. On the Earthquake Shocks of 17th August, 1892, in the British Isles, and in Central France a week later.. .. 197
Discussion 199
Temperature Observations in a deep Coalpit sinking in Belgium, with Analysis and Temperature of a Spring of Water at a depth of 3,773 feet 204
Paper. Mr. Charles Roeder. List of Shells from the Lower Boulder Clay at Heaton Mersey, near Manchester, with remarks thereon 206
Ordinary Meeting, March, 1893 211
Fossil Plants from the Cannel of the Wigan Four Feet Mine. Mr. George Caldwell 211
Paper. Mr. James Tonge, F.G.S. On the Deepening of a Shaft at Hulton Colliery, Lancashire 216
Discussion 219
Paper. Mr. George Wild. Method and Value of Fossil Collection in Coal Mining 222
Discussion 226
Paper. Mr. Mark Stirrup, F.G.S. On some recent Estimates of the World's Coal Supply 227
Ordinary Meeting, April, 1893 235
New Members 235
The Glacial Drift Deposit at Sandbach 235
Fossils from the Lower Coal Measures 237
Paper. Mr. Joseph Dickinson, F.G.S. On Outbursts of Soft Coal and Gas in the Royley Seam, at the Nook Pit, Broad Oak Colliery, Ashton-under-Lyne 239
Discussion 255
Extra Meeting, May, 1893.. 267
New Members 268
The Drift Sands at Sandbach 268
Paper. Mr. C. E. De Rance, Assoc.Inst.C.E., &c. On the Results of the Salt Union Boring, at Marston, near Northwich 269
Discussion 292
Ordinary Meeting, Wigan, May, 1893 303

Digitized by Google

PAGE
New Member 303
Paper. Mr. Thomas Grundy. On the Deepening of a Shaft under the Cages at Wigan Junction Colliery 303
Discussion 306
The Substitution of Iron and Steel for Timber in Mines. Discussion 310
Mis-Shots in Mines. Discussion 311
Ordinary Meeting, June, 1893 315
Additions to Library 315
Paper. Mr. Mark Stirrup, F.G.S. Further notes on Boulders from the Coal Measures 321
Discussion 330
Discussion upon Mr. Dickinson's Paper "On Outbursts of Soft Coal and Gas at the Broad Oak Colliery, Ashton-under-Lyne." 332
Annual Meeting, October, 1893 361
Report of the Council, Session 1892-93 361
Treasurer's Balance Sheet 366
List of Papers read during the Session 1892-93 367
Officers and Council for Session 1893-94 370
Presentations to the Library, 1892-93 375
Societies with which Transactions are exchanged 385
Past Presidents of the Society 391
List of Members 392
Ordinary Meeting, November, 1893 403
Paper. Mr. William Saint, H.M.I.M. On recent Improvements in Mining Machinery and Appliances 404
Discussion.. 421
Report of the Delegate to the British Association Meeting at Nottingham, September, 1893. By Mr. Mark Stirrup, F.G.S. 422
Notes on Outbursts of Soft Coal and Gas. By Mr. W. S. Gresley, F.G.S. 429
Discussion 433
Singular Nodules and Ice Worn Stones found in the Boulder Clay of Piethorn Valley 436
Discussion 439

Digitized by Google

PAGE

Ordinary Meeting, December, 1893 443
New Members 443
Bitumen from a Coal Seam at Poynton, near Stockport .. 444
Presentation of Fossils.. 447
Paper. Mr. C. E. De Rance, Assoc.Inst.C.E., F.G.S., &c. On the Boring for Coal on the Freeholders' Estate at Hazel Grove 452
Paper. Mr. G. H. Kinahan, M.R.I.A., &c. On the Iron Ore Measures of County Antrim 458
Wigan Meeting, January, 1894 467
New Members 467
Paper. Mr. Charles H. Higson. On the Walker Patent "Indestructible" Ventilating Fan and Engines, as erected at the Park Collieries, Garswood; their Construction, Arrangement, and Efficiency.. 468
Discussion 480
Meeting at Owens College, February, 1894 487
Paper. Professor Boyd Dawkins, M.A., F.R.S. On the South-Eastern Coalfield at Dover 488
Discussion 507
Ordinary Meeting, February, 1894 511
New Members 511
Boulder Clay Nodules and Ice-worn Stone 512
Discussion.. 516
Paper. Mr. C. H. Williams. Practical Notes on the Mining of Iron Ores, Bauxite, &c., of County Antrim 518
Paper. Mr. William Peile. Notes and Analyses of Iron Ores and Bauxite, from the Crommelin Mines, County Antrim 522
Paper. Mr. Geo. G. Blackwell. Notes on Bauxite of County Antrim and its uses in the Manufacture 525
Discussion.. 527
Ordinary Meeting, March, 1894.. 535
Paper. Mr. William Watts, F.G.S. Meteorological Observations of 1893, with Notes of Temperature of Moorland Streams 535
Discussion 543

Digitized by Google

PAGE

Paper. Mr. Joseph Dickinson. Notes on Mr. D. Rance's Paper on "The Boring for Coal on the Freeholders' Estate at Hazel Grove." 548
Discussion 551
Ordinary Meeting, April, 1894 553
New Member 553
Paper. Mr. G. C. Greenwell, F.G.S. On Ironstone deposits near Dover 553
Paper. Mr. Joseph Crankshaw. Notes on Hurd's Patent Pneumatic Electric Coal Cutting Machine 558
Discussion.. 569
Paper. Mr. William Watts, F.G.S. Further Notes on Boulder Clay Nodules and Ice-worn Stones 573
Paper. Mr. William Watts, F.G.S. Further Notes on Meteorological Observations of 1893 575
Ordinary Meeting, Wigan, May, 1894 577
New Members 577
The Walker Indestructible Fan 578
Paper. Mr. C. M. Percy. On the Mechanical Ventilation of Mines and Walker's "Indestructible" Fan 583
Ordinary Meeting, June, 1894 589
New Members 589
Septarian Nodules 589
Paper. Professor Boyd Dawkins, F.R.S. On the Geology of the Isle of Man 590
Discussion 606
Paper. Mr. Herbert Bolton, F.R.S.E. Notes on Plant and Fish Remains from the Jarrow Colliery, Co. Kilkenny.. 613
Paper. Mr. Herbert Bolton, F.R.S.E. Note on Myriolepis Hibernica. Traq.. 628
Paper. Mr. Robert Kidston, F.R.S.E., F.G.S. Notes on some Fossil Plants from the Lancashire Coal Measures.. 632
Paper. Mr. Mark Stirrup, F.G.S. The Carboniferous Insects of Commentry, France 652

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XXII. SESSION 1892-93.

THE ANNUAL MEETING of the Members was held at the Rooms of the Literary and Philosophical Society, George Street, Manchester, on Tuesday, October 11th, 1892.

The President: Mr. JAMES TONGE, F.G.S., in the Chair.

The Hon. Secretary (Mr. MARK STIRRUP) read the report of the Council for the past year, as follows:—

REPORT OF THE COUNCIL,

FOR SESSION 1891-92.

The Council, in presenting the Fifty-fourth Annual Report for the consideration and adoption of the members, have the satisfaction to announce that the Society maintains, both financially and numerically, the same strong position which it has been the lot of the retiring Council of many past years to record.

While its roll of members does not escape the inevitable annual loss by death, resignation, and removal, it is gratifying to state that this yearly depletion has been more than compensated by the admission of new members.

Among those whose loss by death the Society has sincerely to regret, as old and faithful supporters, are—Oliver Heywood, J.P., Charles H. Holden, and Christopher James Schofield, J.P., a life member; also Sir A. C. Ramsay,

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late chief of the Geological Survey, who was an honorary member of long standing.

Two ordinary members—Denis Haworth, of Accrington, and W. W. Simpson, of Winkley, near Whalley—have compounded for their annual subscriptions, and thus become life members.

The register now consists of 10 life, 14 honorary, and 198 ordinary members, making a total of 222, being an addition of 6 to last year's list.

During the sessional year, the regular number of monthly meetings has been held—the usual two in Wigan, and the others at the Literary and Philosophical Society's House, 36, George Street, Manchester.

The Annual Réunion of the members at the Manchester Museum, Owens College, was held on Friday, 29th January, 1892, when Professor Dawkins's address on the Coal Discovery at Dover drew together a large and interested audience.

In the list of papers and short communications appended to the Report, it will be seen that the subjects discussed at the meetings have not been of mere local interest, but have much wider application, and, moreover, are strictly on the lines of the objects of the Society, as defined by the Rules, viz., "The Collection and Diffusion of Practical and Theoretical Knowledge respecting Geology and Mining." Several valuable papers on Coal Mining have been contributed by various authors, which have for their object the prevention of accidents, the ventilation of mines, and the adaptation of mechanical inventions and apparatus for the better and safer working of our coalpits.

The President's Address on "The Future of Coal Mining" dealt with several important economical problems connected therewith, and while foreshadowing the probable difficulties of the future, suggested means of alleviation.

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The rapid exhaustion of the principal Coal Fields of Great Britain, especially the more accessible and better seams, has drawn public attention to the vital question of the duration of our coal supply—a question of the first importance to the future wellbeing of the nation. Such papers, therefore, as that of Professor W. Boyd Dawkins on the "Further Discovery of Coal at Dover," and that of Mr. G. C. Greenwell, F.G.S., on "The Probability of Coal being found South of the Mendips," have been very opportune and valuable, as indications of resources still untouched.

The Thermometrical Observations of the Air and Water at the Oldham Corporation Reservoirs taken by our member Mr. Watts (the results of which have been brought before the Society during this and previous years) are now concluded, and the records handed over to the Committee of the British Association appointed for their collection and analysis.

Papers of more purely geological interest have been contributed by Mr. George Wild, on the Lower Coal Measures of Lancashire, and by Mr. Robert Kidston, F.G.S., on the Fossil Plants of the Lancashire Coal Measures, both of which may be considered as valuable contributions to the special work which the Society has at present in hand, that of the systematic collection of the fossils of the Lancashire Coal Field, with the object of recording their distribution and order of occurrence. This work, if thoroughly carried out, will undoubtedly be of great assistance to the miner in the identification of the different seams of coal in faulted or unknown ground, as well as of great interest to the geologist; but to attain this desirable end, the hearty help and goodwill of those members, who have it in their power to aid, will be required.

The paper sent by our trans-Atlantic member, Mr. W. S. Gresley, F.G.S., with a detailed section of the "Main

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Coal" or Moira Seam of Leicestershire, gives an admirable idea of the varying and often complex character of a coal seam.

The superficial accumulations of the district, such as are known under the name of Drift or Glacial Deposits, have received some attention, as will be seen by the communications of Mr. Charles Roeder and Mr. Herbert Bolton, both of which disclose facts somewhat at variance with prevailing theories as to the mode of origin of these puzzling beds.

Excursions.—During the summer two excursions have been organised. The first one took place on Saturday afternoon, 2nd July, 1892, to the Piethorn Valley, near Rochdale, to view the outcrop of the Lower Coal Measures there.

This excursion (suggested at the reading of Mr. Wild's paper) was ably conducted by Mr. William Watts, F.G.S., who pointed out the Woodhead Hill rock *in situ*, and then in descending order, the Lower Coal seams on Elpit Edge to the Rough Rock of the Millstone Grit.

The second excursion, on Monday, September 5th, under the leadership of the Hon. Secretary, Mr. Mark Stirrup, F.G.S. (in conjunction with the Manchester Geographical Society), was to the Manchester Ship Canal, Eastham Section, *viâ* Northwich, down the River Weaver, to Weaver Pool, where is springing up the new town of Saltport.

This excursion, while permitting a passing glance at the importance of the salt industry of Northwich, afforded an excellent opportunity of seeing the magnitude of the Ship Canal works at present in operation at the mouth of the River Weaver, and of inspecting the navigable portion of the Canal to its terminus at Eastham. The large number of members present evinced the unabated interest taken in this enterprise.

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In February last the Federated Institute of Mining Engineers held one of their general meetings in Manchester, and your Council had great pleasure in accepting the invitation of the Institute to assist in making the necessary arrangements for the visit. The Council take this opportunity of thanking those members and friends who so liberally opened their works and collieries for inspection, thus aiding much in making the visit of the Institute a profitable and successful one.

Library.—This important department of the Society, the Council are pleased to be able to say, is now in a satisfactory condition, owing to the rearrangement of the books and the publication and issue of the new catalogue.

The library offers to the members, for consultation and home reading, a selection of the best standard works on geology, mining, and allied subjects.

The entire series of the Geological Survey Maps of the Lancashire Coal Field, both on the one-inch and six-inch scales, are also available for reference at the rooms in George Street.

The publications of kindred societies, both at home and abroad, are being constantly received in exchange, thus forming a valuable link of communication with the Colonies, the United States, and Europe.

Among the donations to the library during the year may be especially mentioned that of a series of standard geological works by our honorary member and very good friend Mr. William Whitaker, F.R.S.

Several additions have also been made by purchase, including, among others, the three supplements of "Dyas," by Professor Geinitz, and the recently published memoirs of the Geological Survey.

The "American Geologist" has also been added to the serials.

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The Treasurer's Statement demonstrates the good financial position of the Society, and shows that after the satisfaction of all claims a balance remains to credit of £205 13s.; this, however, is in great part made up of the balance of £130 12s. 6d. brought forward last year.

A noticeable feature of the account is the amount of £11 15s. 3d. received for "Transactions" sold.

The Council have been in correspondence with the Technical Instruction Committee of the Lancaster County Council as to the best means of providing technical instruction for miners, which it is hoped may lead to the appointment of additional and high-class lecturers to the mining districts of the county.

The Council, in reviewing the excellent work of the past year, take encouragement for the future, and in order to maintain the present prosperous condition and usefulness of the Society, would urge upon the members the desirability of a more frequent attendance at the meetings, which offer a most convenient and efficient means of exchanging views and discussing subjects of both practical and scientific interest.

The value and importance of an organisation such as the Manchester Geological Society, to a community like that to which it appeals, can not be over-rated,—it has the means of influence in many directions which should not be lost sight of by its members, and which it should be their duty and privilege to maintain.

The Hon. Treasurer, Mr. Henry M. Ormerod, presented his financial statement, which was read by Mr. Stirrup, as follows:—

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MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET.

Dr.

1891-2.	Abstract of Receipts.	£	s.	d.
Oct. 1.—To	Balance brought forward	130	12	6
,,	Birkenhead Dividends	23	8	0
,,	Lancashire and Yorkshire Dividends	15	12	0
,,	Transactions Sold	11	15	3
,,	Bank Interest	2	0	1
,,	Commutation of Subscription—			
	W. W. Simpson	9	0	0
	David Haworth	9	0	0
,,	Subscriptions and Arrears	206	0	0
,,	Two New, Half each	1	0	0
,,	Bonus, Insurance Office	0	9	4
		£408	17	2

Cr.

1891-2.	Abstract of Payments.	£	s.	d.
By	Library	10	5	9
,,	Transactions	90	8	6
,,	Reporters	12	12	0
,,	Circulars and Stationery	14	10	7
,,	Postages and Carriage of Parcels	29	15	8
,,	Meetings, Extra	3	7	0
,,	Collector's Commission	10	7	0
,,	Rent	30	0	0
,,	Insurance	0	12	6
,,	C. Hargreaves, Attendance	1	5	0
		£203	4	0
,,	Balance carried forward	205	13	2
		£408	17	2

The Investments consist of £600 Four per Cent. Guaranteed Stock of the Birkenhead Railway, and £400 Lancashire and Yorkshire Consolidated Preference Stock in the names of Henry Mere Ormerod and Clegg Livesey.

Audited and found correct,

HENRY M. ORMEROD, Treasurer.

1st October, 1892.

} Auditors.

October, 1892.

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It was moved by Mr. Dickinson, seconded by Mr. Garside—"That the Report and Balance Sheet now read be approved and adopted." Carried unanimously.

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1891-92.

1891.

October. Stirrup, M. "On some Fossiliferous Slabs of Marl Slate."

Huffam, — "The Electric Lighting of Miners' Lamps."

November. Tonge, James. "The Future of Coal Mining."

Ashworth, James. "Notes on Recent Accidents from Blasting in Coal Mines."

Stirrup, Mark. "Report of the Delegate to the British Association Meeting at Cardiff, August, 1891."

December. Wild, George. "On the Lower Coal Measures of Lancashire."

Kidston, Robert. "Notes on some Fossil Plants from the Lancashire Coal Measures."

1892.

January. Grundy, James. "On Accidents in Coal Mines."

Orsman, William. "On the Detonation of High Explosives."

Dawkins, Professor W. Boyd. "On the further discovery of Coal at Dover, and its bearing on the Coal Question." (Given at the Owens College.)

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February. DeRance, C. E. "Notes on Triassic Borings."

Williamson, Prof. W. C. "On his Earlier Palæontological Work."

March. Watts, William. "Thermometrical Observations of Atmospheric Air and Water, at Piethorn and Denshaw."

Gresley, W. S. "A Typical Section, taken in detail, of the 'Main Coal' of the Moira or Western Division of the Leicestershire and South Derbyshire Coalfield."

April. Sutcliffe, Richard. "The Practical Working of Coal Cutting Machines."

Bolton, Herbert. "On the Finding of Marine Shells in the Boulder Clay of Bacup."

May. Woodworth, B. "On his Patent Controlling Apparatus, &c."

Hopton, William. "On a New Design of Ventilating Fan for Collieries."

June. Greenwell, G. C. "On the probability of Coal being found South of the Mendips in Somersetshire."

Roeder, Charles. "Notes on Marine Shells derived from the Post-Pliocene Deposits of Manchester and District."

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NEW ORDINARY MEMBERS.

Dobb, Thomas G.
Dodds, James
Fallows, William
Finch, John
Fletcher, Arthur
Gerrard, John
Goodwin, Joseph
Grammer, F.
Gregson, G. Ernest
Haworth, Denis
Jamieson, Walter
Marshall, Herbert S.
Miller, Arthur
Mills, David
Roeder, Charles
Roscoe, George
Scowcroft, Thomas
Sutcliffe, Richard
Tonge, Alfred J.
Turner, William
Whitehead, J. J.

NEW LIFE MEMBERS.

Haworth, Denis
Simpson, W. W.

MEMBERS DECEASED.

Heywood, Oliver
Holden, Charles H.
Ramsay, Sir A. C.
Schofield, C. J.
Taylor, Reuben
Wallwork, John

MEMBERS RESIGNED.

Evans, Walter
Grimke, Theodore D.
Hetherington, Joseph
Hindley, C. E.
Rigby, William
Sopwith, Arthur
Tomlinson, Thomas

MEMBERS REMOVED FROM THE LIST.

Howell, John
Topping, Walter

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ELECTION OF OFFICERS.

Before proceeding with the election the Hon. Secretary read the rule bearing on this matter, after which the names of those gentlemen proposed to fill the various offices were duly moved and seconded, resulting in the following members of the Council being declared unanimously elected :—

President:

MASKELL WILLIAM PEACE, F.G.S.

Vice-Presidents:

R. T. BURNETT, F.G.S.
GEORGE PEACE.
WILLIAM SAINT, H.M.I.M.
ROBERT WINSTANLEY.

Hon. Treasurer:

H. M. ORMEROD, F.G.S.

Hon. Secretary:

MARK STIRRUP, F.G.S.

Members of the Council:

HENRY BRAMALL, M.Inst.C.E.
RICHARD CLAY.
SAMPSON GARSIDE.
JAMES GRUNDY, H.M.I.M.
G. H. HOLLINGWORTH, F.G.S.
ISAIAH JOHNSON.
G. H. PEACE, M.Inst.C.E.
JOHN RIDYARD, F.G.S.
HARRY SPEAKMAN.
WILLIAM WATTS, F.G.S.
GEORGE WILD.
H. A. WOODWARD.

Auditors:

ALFRED PILKINGTON. | CLEGG LIVESEY.

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The CHAIRMAN said: There is one little matter I should like to say a word upon before the meeting separates, that is—that the collection of fossils from the Lancashire coal-field, which a few of us were so enthusiastic about at the beginning of the year, has not progressed as satisfactorily as it might have done, and one suggestion which has been made will have the consideration of the Council when it next meets. But what I have found in the course of my attempts at collecting is that there exists in the minds of some Managers a fear lest it should be known that they are assisting in this work. I am speaking from actual observation. Gentlemen who have given me fossils have asked that their names might not be associated with them, lest their employer should suppose that they were spending their time collecting fossils instead of attending to their duties. If the Secretary were to write to such members of this Society as are colliery proprietors, asking that facilities might be given for the collection and preservation of fossils, I think one of the greatest difficulties in the way would be removed. If it became known that Managers had permission, and not only permission but the approval of their employers, in assisting this Society and the work it has undertaken, I think it would be a good thing. I thought by the end of this year specimens would have been sent in to us by scores, or hundreds, but they have dropped off quite suddenly. There certainly has been a considerable number collected, but it is small, I am sure, in comparison with the number that might have ceen collected during the last twelve months.

Mr. GRUNDY asked what had been done with the specimens which had been collected?

The CHAIRMAN: About 70 of the best and most typical ones have been sent to the Owens College Museum.

Mr. GRUNDY: But there are others, I suppose, which have been received but not yet sent there?

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The CHAIRMAN: There are a few. It is intended that specimens shall be first shown at these meetings, and if desirable that papers should be read upon them; after that they are sent to the Museum.

Professor DAWKINS said: I should just like to say, with regard to this point, that, of course, the Museum is, in a sense, the property of this Society; and I am sure—speaking on the part of the Museum—I shall be only too glad to welcome any addition which could be made to the very fine collection which we have at the present time. That collection, which was got together mainly by the Geological Society of Manchester, is one of the best carboniferous collections in the whole world. It would be a great pity if the idea were to get afloat that people were wasting their time by adding to it.

Mr. GERRARD: I beg to move that a hearty vote of thanks be tendered to the retiring President and Council for their services. The present position of this Society, both in point of number of members, in point of papers submitted to the meetings, and its financial position, reflects the greatest credit upon the Council. They leave office with the greatest possible credit, and as ordinary members of the Society it is only fitting that we should tender to them our hearty thanks.

Mr. CRANKSHAW seconded the motion, which was passed unanimously.

The CHAIRMAN acknowledged the compliment.

This concluded the special business of the Annual Meeting, after which the Election of New Members was proceeded with.

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NEW MEMBERS.

The following gentlemen, whose names had previously been submitted as candidates for membership, were balloted for and duly elected Ordinary members of the Society :—

David Howell F. Mathews, H.M. Inspector of Mines, Newton-le-Willows.

Moses Morris, Swan Lane, Hindley.

Alexander H. Ward, Colliery Manager, Coppull, Chorley.

Frank Dutton, Chemist, Crown Street, Bolton.

James Thompson, Colliery Manager, Westhoughton, Bolton.

THE ORDNANCE SURVEY OF GREAT BRITAIN AND THE GEOLOGICAL SURVEY OF THE UNITED STATES.

Mr. Stirrup referred to the public complaints which had been made at various times respecting the condition of the Ordnance Survey Maps, which had often been contrasted unfavourably with those of foreign Governments. They are, he said, many of them old in date, dear in price, and not up to the level of modern requirements. Many suggestions had been offered with a view to an alteration of this state of things, and the matter has been, as you are aware, brought under the notice of the House of Commons by Mr. Roby, one of our local Members of Parliament, so that we are living in hope of seeing both better and cheaper maps some day. Whilst we have thus need to complain of the shortcomings of our own Government survey, we have had nothing but praise to bestow upon the work done in America. The valuable series of maps and publications having reference to geology, palæontology, and economic products of the various States of the Union, publications which have been distributed with so liberal a hand all over Europe, have usually been

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appreciated as the outcome of the scientific activity of a young and wealthy nation. It is therefore with feelings of regret that one learns that the issue of these publications has received a sudden check—a fact which may not be known to all here.

It appears that towards the close of the last session of Congress the usual vote of funds for the U. S. Geological Survey was refused, the result being that all field work has been suspended, and many of the staff been discharged.

The cause of this sudden action on the part of Congress seems to be due to the action of one or two Congressmen, apparently influenced by a caustic pamphlet by Mr. Jules Marcou, freely distributed at Washington, calling in question the conduct of the Survey and that of the Palæontologist Professor Marsh.

Whether this pamphlet has more than personal or private jealousy as a motive is not clear, and one must wait the result of the finding of the Committee which was appointed to report on the Survey to the next session of the House of Representatives. Certain it is, that should the work of the Survey be thus brought to a close, it will be nothing short of a calamity in the history of geology and palæontology.

Professor W. Boyd Dawkins: It would indeed be a great misfortune if the American Survey were to stop, but I do not think that it will; it is merely a question of re-organisation. I do not think the actual survey work will be stopped in the new Congress. The method of working it seems to have been to subsidise nearly every geologist in the United States. The work has been very expensive; and I can understand any reformer in view of the elections making a dead set against it on the ground of economy. With regard to the Ordnance Survey of this country, I think we ought to be exceedingly glad that the movement for setting that on a

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satisfactory, reasonable, and civilised basis has originated in Manchester. We have been altogether independent of those social influences which have maintained that institution in its rottenness in the South of England; and I am sure all the civil engineers in this country will ultimately thank us for doing our best to bring up our maps to the level of those of other countries. The present condition of the English maps is disgraceful. The information given on them is of the roughest sort, and the contour lines and altitudes are very few and far between. Unfortunately the present Commission has been narrowed down to a mere departmental enquiry. It is not a general Commission, but a departmental one, and unfortunately officialism, which we are all acquainted with, is strongly rampant on it. The only way a reformation can be effected will be to make the public voice heard not only in the Commission, but outside it; and I am extremely glad to see the line taken by such a powerful organ of opinion as the *Times;* and I feel that for us here, who are so very much interested in the matter, it is our duty to go on pegging away, and not to cease agitating till we have the maps put in such a form that they will no longer be such a disgrace as they are at present. Everyone must feel how inadequate they are now, how out of date, and how miserably executed the new ones are.

Mr. Burnett: I should like to say also how very much we should regret if this American work were not to be resumed, because those who are engaged in palæontological research in this country, know how very much the American work has aided the reading of the English work; especially with regard to the passage of the reptiles to the birds—the toothed birds—one cannot overestimate the value of the work already done, and that which may yet be done. With regard to the English maps, I can only support what

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has been said as to their character, and I hope a great improvement will result from the present agitation.

Mr. GERRARD: Recently, within the last two months, the North of England Institute of Mining Engineers has appointed a Committee with a view to bring what influence it can to bear on this important question. They have sent out circulars to members asking for information. Might not this Society take some step of a similar kind?

Mr. STIRRUP: So far as I believe, the matter has been in the hands of private individuals. It is a question whether some collective action would not be advisable.

In reply to a question,

Mr. STIRRUP said: Our townsman, Mr. H. T. Crook, C.E., has taken a foremost part in the work; he has tested the deficiencies of the maps, and on various public occasions has called prominent attention to their shortcomings. His strictures have been answered occasionally by one of the heads of the department. I am inclined to think that no further step can be taken until we know the result of the Commission which has been appointed, and which, I presume, will report to Parliament.

Professor DAWKINS: Yes, they will report, but the time is not specified; and one knows what that means. I think it would be of great assistance to Mr. Roby, who I know is determined to see this matter through, if some such Committee as has been suggested were formed; and I have no doubt when the new Council meet, they will take the questions into consideration.

This concluded the business of the Meeting.

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APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1891-92.

Belfast Natural History and Philosophical Society.—Report and Proceedings for Session 1890-91. *From the Society.*

Bristol Naturalists Society.—Proceedings. Part 1, Vol. VII.; also List of Officers, Annual Report, &c., 1892. *From the Society.*

Cambridge.—Woodwardian Museum.—26th Annual Report of Lecture Room Syndicate; Type Fossils in the Woodwardian Museum. By Henry Woods. *From Professor Hughes, M.A.*

Cardiff Naturalists Society.—Report and Transactions. Part 1, Vol. XXIV. *From the Society.*

Chester Society of Natural Science and Literature.—21st Annual Report. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Transactions. Part 6, Vol. XVI., and Parts 1-7, Vol. XVIII. of Proceedings. *From the Society.*

Cornwall.—Royal Institute of. Journal, Part 1, Vol. XI. *From the Council.*

Edinburgh Geological Society.—Transactions. Part 3, Vol. VI. *From the Society.*

Edinburgh Royal Physical Society.—Proceedings, Session 1890-91. *From the Society.*

Essex Naturalist.—Nos. 7-12, Vol. V., and Nos. 1-8, Vol. VI. *From the Essex Field Club.*

Halifax.—Yorkshire Geological and Polytechnic Society. Proceedings. N.S., Part 1, Vol. XII. *From the Society.*

Hertfordshire Natural History Society and Field Club.—Transactions. Parts 4-7, Vol. VI., and Part 1, Vol. VII. *From the Society.*

Leeds.—Yorkshire Naturalists' Union. Transactions. Parts 10-16, for years 1885, 1886, 1887, 1888, 1890, and 1891. *From the Society.*

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Leeds Geological Association.—Transactions for 1890-91. *From the Association.*

Leeds Philosophical and Literary Society.—Annual Report for 1891-92. *From the Society.*

Leicester Literary and Philosophical Society.—Transactions. Parts 9-11, Vol. II. *From the Society.*

Liverpool Geological Association.—Journal, Session 1890-91. *From the Association.*

Liverpool Geological Society.—President's Address—Pamphlet *Presented by Dr. Ricketts (Birkenhead).*

Liverpool Geological Society.—Proceedings. Part 4, Vol. VI. *From the Society.*

Liverpool Free Library and Walker Art Gallery.—39th Annual Report.

London Geological Society.—Quarterly Journal. No. 188, Vol. XLVII., and Nos. 189-191, Vol. XLVIII. *From the Society.*

London Geologists' Association.—Proceedings. Parts 6-8, Vol. XII. *From the Association.*

London Geological Magazine.—Nos. 328-339, Vol. IX. *Purchased.*

London.—Institute of Mechanical Engineers.—Proceedings. Nos. 4-5 for 1891, and Nos. 1-2 for 1892. *From the Institute.*

London.—Iron and Steel Institute.—Journal. No. 2, 1892. *From the Institute.*

London.—Palæontographical Society.—Vol. XLV., 1891. *Purchased.*

London.—Royal Institution of Great Britain.—Proceedings. Part 2, Vol. XIII. *From the Institution.*

London.—Royal Society.—Proceedings. Parts 303-309, Vol. L., also 310-313, Vol. LI. *From the Society.*

London, The Colliery Guardian.—No. 1624, Vol. LXIII. *From the Editor.*

London.—Iron and Coal Trades Review. No. 1261, Vol. XLIV.

Manchester Association of Engineers.—Transactions. *From the Association.*

Manchester Geographical Society.—Journal. Nos. 4, 6, 7, 8, and 9, Vol. VII. *From the Society.*

Manchester and Salford Sanitary Association.—Annual Report for Manchester and Salford, 1891. *From the Association.*

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Manchester Field Naturalists and Archæologists.—Report and Proceedings for 1891.

Midland Institute of Mining Engineers.—Transactions. Parts 111-12, Vol. XII., and Part 113, Vol. XIII. *From the Council.*

Newcastle-upon-Tyne, North of England Institute of Mining and Mechanical Engineers.—Transactions. Parts 2-4, Vol. XL., and Parts 1-4, Vol. XLI. *From the Institute.*

Owens College (Manchester).—Classification of Animal Kingdom, Embryological Models, and Guide to Contents of Museum. Calendar for the Session 1892-93. *From the College.*

Rochdale Literary and Scientific Society.—13th Annual Report. *From the Society.*

Salford.—43rd Annual Report of Museum and Libraries, 1890-91. *From the Museum.*

Scotland.—Mining Institute of. Transactions. Parts 5-9, Vol. XIII., and Parts 1-3, Vol. XIV. *From the Institute.*

Scotland.—Natural History Society of Glasgow. Proceedings and Transactions. Part 2, Vol. III. *From the Society.*

Swansea.—South Wales Institute of Engineers. Proceedings. Parts 4-6, Vol. XVII. *From the Institute.*

Warwickshire Natural History Society.—50th Annual Report. *From the Society.*

Whitaker, W., F.R.S., The following Books and Pamphlets Presented by :—

Bibliographia Zoologiæ, Vols. 1-4. By Agassiz.

The School Manual of Geology, 1881. By J. B. Jukes.

Geological Researches, 1834. By De la Beche.

Students' Manual of Geology, 1872. By J. B. Jukes and A. Geikie.

Students' Manual of Geology, 1862. By J. B. Jukes.

Manual of Geology, 1855. By Professor Phillips.

Bridgewater Treatise, Geology and Mineralogy. By Dr. Buckland.

Introduction to Geology, 1838. By R. Bakewell.

A Geological Manual, 1833. By De la Beche.

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A Geological Essay on Theory of Earth. By J. Kidd.

A Memoir to the Map and Delineation of Strata of England and Wales with part of Scotland, 1815. By William Smith.

Reliquiæ Diluvianæ. By Dr. Buckland.

Greek Geology Pamphlet. By John Young.

Geological Survey of United Kingdom. Pamphlet. By Jukes.

Report by Lieutenant-Colonel W. G. Dawson on Finding Coal in Oxfordshire. Pamphlet.

Passages in History of Geology. Pamphlet. By A. C. Ramsay.

Modern Geology. Extract. Journal of Science, Vol. IV.

Discussion on Fauna of British Central Africa. Pamphlet. (From Proceedings of Zoological Society of London.)

On Specimens from Permian Breccia of Leicestershire. Pamphlet. Reprint from the Midland Naturalist. By W. S. Gresley. *From the Author.*

A hitherto undescribed Phenomenon in Hæmatite. Pamphlet. By W. S. Gresley. *From the Author.*

Report of British Association for Advancement of Science. Cardiff Meeting, 1891. *From the Association.*

On the Circulation of Underground Waters. 15th, 16th, and 17th Reports. Pamphlets. *Presented by C. E. De Rance.*

Annals of British Geology, 1890. By G. F. Blake, F.G.S. *Purchased.*

Volcanoes, Past and Present. By Professor Edward Hull. *From the Author.*

Official Year-Book of Scientific and Learned Societies of Great Britain and Ireland, 1891. *Purchased.*

Report on an Explosion at Malago Vale Colliery, Bristol, 1892. *From J. S. Martin, Esq.*

Coal Dust and Colliery Explosions. Pamphlet. By James Ashworth.

Safety Lamps, and also the Detection of Firedamp. Pamphlet. By James Ashworth.

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Report, Manchester and Ireland District Mines, No. 6, 1891. *Presented by J. Dickinson, Esq.*

Report, North Staffordshire District Mines. *Presented by W. N. Atkinson, Esq.*

CANADA AND U.S. AMERICA.

Canada, Hamilton.—Journal and Proceedings of the Hamilton Association. No. 8. *From the Association.*

Canada, Ottawa.—The Canadian Mining Review. Nos. 9-12, Vol. X., and Nos. 1-8, Vol. XI. *From the Editor.*

Canada, Ottawa.—The Canadian Mining Manual, for 1892. *From the Editor.*

Canada.—Geological and Natural History Survey of Canada.—Contributions to Canadian Micro Palœontology. Part 4. *From the Director of the Survey.*

Canada.—Royal Society of Canada.—Transactions, Notes on Specimens of Parka decipiens, and Collections of James Reid; also Additional Notes on Devonian Plants from Scotland. *From Sir William Dawson.*

Canada, Toronto.—Canadian Institute.—Annual Report, Session 1891. An Appeal to the Institute on the Rectification of Parliament. By Sandford Fleming, C.M.G. *From the Institute.*

U.S.A., Cambridge.—Harvard College.—Bulletin of the Museum of Comparative Zoology. Nos. 1-4, Vol. XXII., and Nos. 1-3, Vol. XXIII. *From A. Agassiz.*

U.S.A., Chapel Hill, North Carolina.—Elisha Mitchell Scientific Society.—Journal. Part 2, Vol. VIII. *From the Society.*

U.S.A., Denver.—Colorado Scientific Society.—Proceedings. Part 3, Vol. III. Report on the Technical Determination of Zinc, 1892. Extracts from the Society's Proceedings—On the Nature of Chemical Elements (by C. S. Palmer); On the Ore Deposits of Newham Hill (by J. B. Farish). *From the Society.*

Halifax, N.S.—Nova Scotian Institute of Science.—Proceeding and Transactions. Part 1, Vol. I. *From the Institute.*

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U.S.A., Indianopolis.—Department of Geology and Natural History, Indiana.—16th Annual Report for 1888; also Resources and Natural Gas Map of Indiana. *From the State Geologist.*

U.S.A., Minneapolis.—Academy of Natural Science.—Bulletin No. 2, Vol. III. *From the Academy.*

U.S.A., Minneapolis.—The American Geologist.—Nos. 1-6, Vol. IX.; also Nos. 1-3, Vol. X. *Purchased.*

U.S.A., Montgomery, Ala.—Geological Survey of Alabama. Report on the Cahaba Coalfield. By Squire. *Presented by S. S. Platt.*

U.S.A., New York.—American Museum of Natural History.—Bulletin No. 2, Vol. III.; also Annual Report of the President, &c., for 1892. *From the Museum.*

U.S.A., Philadelphia.—American Institute of Mining Engineers.—List of Officers, Members, Rules, &c., for 1892. *From the Institute.*

U.S.A., Philadelphia.—Academy of Natural Sciences.—Proceedings. Parts 1-3. *From the Academy.*

U.S.A., Philadelphia.—Franklin Institute.—Journals. Nos. 793-801, Vols. CXXXIII. and CXXXIV. *From the Institute.*

U.S.A., Scranton, Pennsylvania.—The Colliery Engineer.—Nos. 6-12, Vol. XII.; also Nos. 1-2, Vol. XIII. *From the Editor.*

U.S.A., Philadelphia, Pennsylvania Geological Survey. Atlas Southern Anthracite Field. Parts 4, 5, 6. *From the Survey.*

U.S.A., Springfield.—Statistics of Coal in Illinois.—9th Annual Report, for 1891. *From W. S. Gresley.*

U.S.A., Washington.—United States Geological Survey.—Bulletins. Nos. 67 to 81, 1890-91; also 10th Annual Report, 1888-9, Geology Part 1, Irrigation Part 2. *From the Director of Survey.*

U.S.A., Washington.—Smithsonian Institution.—Report of National Museum, for 1889-90. *From the Board of Regents.*

INDIA.

Calcutta.—Records of the Geological Survey of India.—Part 4, Vol. XXIV., and Parts 1-2, Vol. XXV. *From the Governor General of India in Council.*

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AUSTRALIA.

Adelaide.—Royal Society of South Australia.—Part 2, Vol. XIV., Part 1, Vol. XV. *From the Society.*

Sydney.—Royal Society of New South Wales.—Journal and Proceedings. Vol. XXV., 1891. *From the Society.*

Sydney.—Geological Survey of New South Wales.—Department of Mines.—Records Part 4, Vol. II.; also Palæontology, No. 8; Report of Trustees of Australian Museum, for 1890. *From the Hon. the Minister of Mines.*

Sydney Public Free Library.—Report for 1891.

Sydney.—Annual Report of the Department of Mines and Agriculture of New South Wales, for 1891.

Sydney.—The Australian Mining Standard. A Record of Mining, Financial, and Engineering Progress. Nos. 196, 197, and 198, Vol. VIII. *From the Editor.*

Victoria.—Report and Statistics of Mining Department of Victoria, for 1891 and 1892. *From the Government.*

FOREIGN.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft. Heft 3-4, Vol. XLIII., and Heft 1-2, Vol. XLIV. *From the Society.*

Berlin.—Gesellschaft für Erdkunde. Zeitschrift, No. 6, Vol. XXVI., and No. 1, Vol. XXVII. Verdhandlungen, Nos. 9-10, Vol. XVIII., and Nos. 1-3-4-5, Vol. XIX. *From the Society.*

Brussels.—Société Malacologique de Belgique. Annales, Vol. XXV., 1890; Procés-Verbaux, September to December, 1890, and January to June, 1891. *From the Society.*

Buenos Ayres.—Estadistico del Commercio de Buenos Ayres. Bulletin, Ano I. Mensuel de Statisque Municipale, 1892. *From the Government.*

Christiania.—Archiv for Mathematik og Naturvidenskab. Fjortende Bind, Hefts 1-4, and Femtende Binds. Hefts 1-3, for 1890-91-92. *From the University.*

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Freiburg in Baden.—Bericht der Naturforschenden Gesellschaft. Heft 1-2, Vol. II., and Heft 1-5, Vol. IV. *From the Society.*

Halle, A/s.—Leopoldina, Heft 27. Transactions, Parts 7-13, Vol. XXI., of Nova Acta Deutschen Akademie der Naturforscher. *From the K.L.C.D. Academy.*

Kazan, Russia.—Society of Naturalists of the University of Kazan; Bericht über eine Reise in die Tundra der Halbinsel Kanin in Sommer, 1890; Society of Naturalists, Part 1, Vol. XXIII., Proceedings 1890-91. *From the Society.*

Kieff, Russia.—Memoires de la Société des Naturalistes de Kieff. Nos. 1-2, Vol. IX., and 2-4, Vol. X., 1891. *From the Society.*

Lausanne.—Bulletin de la Société Vaudoise des Sciences Naturelles. Nos. 106-107, Vol. XXVIII. *From the Society.*

Mexico.—Sociédad Scientifica. "Antonio Alzate" Memorias. Nos. 1-4 and 7-10, Vol. V. *From the Society.*

Naples.—Accademia delle Scienze Fisiche e Mathematiche. Rendiconto, Series 2, Nos. 1-3-4-5-6, Vol. VI. *From the Academy.*

Paris.—Annuaire Géologique Universel, Année 1891. Fascs 2-3-4, Vol. VII. Part 1, Vol. VIII. *From Dr. Dagincourt.*

Paris.—La Géologie des Grottes, &c.; Les Katovothres du Péloponése; Nouveaux Rochers des Causses et Vallée de l'Herault; Sous Terre; Troisiéme Campagne. Pamphlets. *Presented by E. A. Martel.*

Roma.—Atti delle Reale Accademia dei Lincei. Rendiconti, Nos. 1 to 12, Vol. I. Di Alcuni Indici Misuration, &c. By L. Bodio, 1892. Rendiconti, Fascs 1-3, Vol. 1. 2nd Semestre. *From the Academy.*

St. Petersburg.—Académie Impériale des Sciences. Memoires, Nos. 4-8, Vol. XXXVIII., and No. 1, Vol. XXXIX. *From the Academy.*

St. Petersburg.—Institut des Mines. Comite Géologique, Bulletin Nos. 9-10, Vol. IX.; Nos. 1-4, Vol. XI.; Nos. 6-9, Vol. XII.; Memoires, No. 2, Vol. XI.; Memoires, No. 1, Vol. XIII. *From the Minister of Domains.*

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BOOKS PURCHASED, 1891-92.

Annals of British Geology, 1890.
Geological Magazine.
The American Geologist.
Official Year-Book of Scientific and Learned Societies, 1891.
Palæontographical Society. Vol. XLV., 1891.
Dyas. 3 Supplements.

Societies with which the Society Exchanges its Transactions, and Institutions and Journals to which a Copy is sent free.

I.—England.

London .....British Museum.
British Museum Library, Natural History Department, Cromwell Road, South Kensington.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologists' Association, University College, Gower Street, W.C.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute, Victoria Mansions, S.W.
Royal Institution of Great Britain, Albemarle Street, Piccadilly, W.
Royal Society, Burlington House, W.
Public Library, Kensington, High Street, W.

Manchester .....The Manchester Association of Engineers.
Field Naturalists' Society, 16, Kennedy Street.
Free Library, King Street.
Literary and Philosophical Society.
Manchester Geographical Society, 44, Brown Street.
The Manchester Museum, Owens College.
The Library, Owens College.
Salford Royal Museum and Library.

Barnsley .....Midland Institute of Mining Engineers.

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Birmingham ....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol .....Naturalists' Society, Ashgrove House, 145, Whiteladies Road (C. K. Rudge, M.R.C.S.).

Cambridge .....Geological Museum, University.
University Library.

Cardiff .....Cardiff Naturalists' Society, 44, Loudoun Square.

Chester .....Society of Natural Science, Grosvenor Museum.

Chesterfield.....Institution of Mining Engineers, 13, Cavendish Street.

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.

Tuckingmill, Camborne.... } Mining Association and Institute of Cornwall.

Essex .....Essex Field Club, 8, Knighton Villas, Buckhurst Hill, Essex.

Exeter.....Albert Memorial Museum.

Halifax .....Geological and Polytechnic Society of Yorkshire.

Leeds .....Philosophical and Literary Society.
Geological Association, Mechanics Institution, Cookridge Street.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Sunny Bank).

Leicester .....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society, Royal Institution.
Science Students' Association, Royal Institution, Colquitt Street.

Newcastle-on-Tyne.North of England Institute of Mining and Mechanical Engineers.

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Newcastle, Staffordshire. .. North Staffordshire Naturalists' Field Club, Rev. T. W. Daltry, M.A., F.G.S., Madeley Vicarage.

Norwich ..... Geological Society, The Museum.

Oxford ..... Bodleian Library.
Radcliffe Library.

North Shields.... Public Free Library.

Rochdale..... Rochdale Literary and Scientific Society, 20, King Street South, Rochdale.

Southampton .... Hampshire Field Club, Hartley Institution.

Stoke-on-Trent .. North Staffordshire Institute of Mining and Mechanical Engineers.

Swansea ..... South Wales Institute of Mining and Mechanical Engineers.

Warwick ..... Natural History Society.

Watford, Herts .. Hertfordshire Natural History Society and Field Club, the Public Library, Watford.

Wigan ..... Free Library.
Mining School.

II.—Scotland.

Dundee ..... Free Library and Museum.

Edinburgh ..... Advocates' Library.
Geological Society, 5, St. Andrew Square.
Royal Society.
Royal Physical Society, 18, George Street.

Glasgow ..... Geological Society, 207, Bath Street.
Natural History Society.

Hamilton ..... Mining Institute of Scotland.

III.—Ireland.

Dublin ..... Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.

Belfast ..... Natural History Society, the Museum.

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IV.—Australia.

Melbourne .....Geological Society of Australasia, 17A, Queen Street.

Public Library of Victoria.

Sydney .....Free Public Library.

Royal Society of New South Wales, 37, Elizabeth Street.

Department of Mines.—The Honourable the Minister of Mines.

Australian Mining Standard, 108, Pitt Street.

V.—Canada.

Hamilton .....Hamilton Association.

Ottawa .....Geological and Natural History Survey of Canada (A. R. C. Selwyn, F.G.S., Director, Museum, Sussex Street, Ottawa).

M'Gill College (Principal, Sir J. W. Dawson, F.G.S.).

Editor of Canadian Mining Review.

Toronto .....Canadian Institute.

Halifax, Nova Scotia .....Nova Scotian Institute of Natural Science.

VI.—United States.

Boston, U.S. ....Free Library.

Chapel Hill, North Carolina, U.S. The Elisha Mitchell Scientific Society.

Columbus, U.S. ..Geological Survey of Ohio (Professor Edward Orton, State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indianopolis, Indiana, U.S. Department of Geology and Natural History. S. S. Gorby, State Geologist.

Madison, Wisconsin .. Wisconsin Academy of Sciences, Arts, and Letters.

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Newhaven, U.S...Professor O. C. Marsh, F.G.S.

New York, U.S...American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).

New York .....American Museum of Natural History, Seventy-seventh Street, and Eighth Avenue.

Philadelphia, U.S...Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104 S Fifth Street.

Scranton, Pa.....Editor of the Colliery Engineer.

Washington, U.S...Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.

Wyoming, U.S...Historical and Geological Society.

VII.—Foreign Societies.

Berlin.....Deutsche Geologische Gesellschaft.
Gesellschaft für Erdkunde. Zimmerstrasse, 90, Berlin, S.W., 12.

Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres ....Officiana Nacional de Commercie.

Calcutta .....Geological Survey of India.

Christiania .....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gessellschaft Isis.

Freiburg in Baden..Naturforschende Gesellschaft (Dr. V. Häcker, Secretary).

Halle, A.S. ....Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

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Lausanne(Suisse). .Société Vaudoise des Sciences Naturelles.

Iglo, Hungary....Société Hongroise de Carpathes (Centrale in Leutschau).

Lille .....Société Géologique du Nord.

Mexico .....Sociedad Cientifica "Antonio Alzate."

Naples .....Royal Academy of Sciences, Bibliothèque de l'Université de Naples.

Paris .....Annuaire Géologique Universel (Dr. Dagincourt, 15, Rue de Tournon).

Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome .....Reale Accademia dei Lincei.

St. Petersburg ..Académie Impériale des Sciences.
Institut des Mines. Comitè Géologique.

Turin .....Acadêmie Royale des Sciences.

VIII.—Scientific Journals, &c.

Iron and Coal Trades Review, 342, Strand, W.C.

Geological Review, W. Topley, F.G.S., Museum, Jermyn Street, London, S.W.

Mining Journal, Fleet Street, London.

Colliery Guardian, 49, Essex Street, Strand, London.

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PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Moseley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E.W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew
1867-8-9, 84-5	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.
1885-6	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S, Assoc.M.Inst.C.E.

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LIST OF MEMBERS.

OCTOBER, 1892.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Withings Lane Colliery, Radcliffe.
1879	Arrandale, John Thomas, The Grange, Coppull, near Chorley.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 24, Mawdsley Street, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Newcastle, Staffordshire.
1881	Aubrey, Richard Charles, 14, St. Paul's Square, Southport.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1889	Beck, William, Ellerbeck Collieries, near Chorley, Lancashire.
1891	*Bell, Thomas*, H.M. Inspector of Mines, Shamrock House, Durham.
1889	Birtwistle, Arthur, Great Harwood Collieries, near Blackburn.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.

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Year of Election.	
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Baxenden, Accrington.
1887	Boole, George, Rainford Colliery, near St. Helens.
1878	Bradford, The Right Hon. the Earl of, Bradford Estate Offices, Bolton (G. R. Carter, Esq., Agent).
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester. *Member of Council.*
1891	Bramhall, Ernest E., Radcliffe Collieries, near Manchester.
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 39, Place de l'Industrie, Brussels.
1877	*Brongniart, Charles*, F.E.S., 9, Rue Linné, Paris.
1880	Brown, Wm. Speakman, 33, Trafalgar Road, Birkdale, Southport.
1859	Bryham, William, J.P., Ince Hall, Wigan.
1881	Bryham, William, jun., Douglas Bank Colliery, Wigan.
1882	Burnett, R. T., F.G.S., Burlington Road, Birkdale, Southport. *Vice-President.*
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., F.G.S., Yew Tree House, Atherton, near Manchester. *Past-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1889	Clay, Richard, Dukinfield Coal Company, Dukinfield. *Member of Council.*
1886	Clifford, William, c/o Roger Hartley, colliery owner, South Side, Pittsburg, U.S.A.
1882	Cockson, Charles, King Street, Wigan.
1878	Cowburn, Henry, 253, West Leigh Lane, West Leigh, near Manchester.

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Year of Election.	
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C.E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1890	Dean, John, Wigan Coal and Iron Co., Limited, Wigan.
1862	* Derby, The Right Hon. the Earl of, Knowsley, Liverpool.
1856	Dickinson, Joseph, F.G.S., South Bank, Pendleton. *Past-President.*
1889	Dobbs, Joseph, Coolbawn, Castlecomer, Co. Kilkenny.
1891	Dobb, Thomas G., Colliery Manager, Hindley, Wigan.
1891	Dodds, James, Crooklands, Lymm, Cheshire.
1892	Dutton, Frank, Crown Street, Bolton.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1891	Fallows, William, Outwood Collieries, Radcliffe.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, Ashton Moss Colliery, Audenshaw, near Manchester.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe,
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.

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Year of Election.	
1889	Foster, John W., 24, Silksworth Terrace, New Silksworth, Sunderland.
1873	Garforth, W. E., F.G.S., Halesfield, Normanton.
1884	Garside, Sampson, Denton and Haughton Collieries, Denton. *Member of Council.*
1892	Gerrard, John, H.M. Inspector of Mines, Worsley.
1889	Gascoyne, Rowland, Brakburn Collieries, Broxburg, near Johannisburg, South African Republic.
1874	*Geikie, Archibald,* LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Woodlands, Parbold, Wigan, *Past-President.*
1882	Glover, B. B., Newton-le-Willows.
1892	Goodwin, Joseph, Hyde Colliery, Hyde.
1890	Green, John, Bamfurlong, Wigan.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1863	Greenwell, G. C., F.G.S., Elm Tree Lodge, Duffield, Derby. *Past-President.*
1890	Gresley, W.S., F.G.S., P.O. Box, 437, Erie, Pennsylvania, U.S.A.
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, 71, Dickinson Road, Rusholme, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1883	Greensmith, T., Moston Colliery, Failsworth, Manchester.
1888	Grundy, James, H.M. Inspector of Mines, 39, Victoria Terrace, Manchester Road, Bolton. *Member of Council.*
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1890	Grundy, Thomas, Wigan Junction Colliery, Abram, near Wigan.

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Year of Election.	
1892	Grammer, F., 10, Egerton Terrace, Stockport Road, Ardwick.
1889	Hacking, James, Bolton Road, Darwen.
1887	Hallas, Geo. H., Wigan and Whiston Coal Company, Ltd., Prescot.
1890	Haines, J. Richard, F.G.S., Adderley Green Collieries, near Longton, Stoke-on-Trent.
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Past-President.*
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1892	*Haworth, Denis, Beech House, Blackburn Road, Accrington.
1878	Hedley, John L., H.M. Inspector of Mines, 22, Hawthorne Terrace, Newcastle-on-Tyne.
1883	Hewitt, John R., Mining Engineer, Derby.
1838	*Heywood, James, F.R.S., F.G.S., 36, Kensington Palace Gardens, London, W. *Past-President.*
1889	Higson, Chas. H., The Park Collieries, Wigan.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1881	Hilton, James, 72, Hawkshead Street, Southport.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester. *Member of Council.*
1884	Howat, Andrew, 6, Bellwood Terrace, Old Trafford, Manchester.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward*, M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.

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Year of Election.	
1889	Iles, John, 76, Church Street, Southshore, Blackpool.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Anderton Hall, near Chorley.
1887	James, J. Stanley, Compania de Rio Tinto, Minas de Rio Tinto, Huelva, Spain.
1891	Jamieson, Walter, M.E., 16, Clonlee, Larne, Co. Antrim.
1883	Jobling, Albert, Spring Wood House, Burnley.
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1890	Johnson, Alfred E., Abram Colliery, Wigan.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton. *Member of Council.*
1882	Johnson, William, Abram Colliery, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1889	Knowles, James. Pearson, Knowles & Co., Wigan.
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury. *Past-President.*
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1882	Knowles, Israel, Ince, Wigan.
1877	* Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.
1886	Knowles, Robert, Ednaston Lodge, near Derby.
1890	Law, Illingworth, Waterfoot, near Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.

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Year of Election.	
1862	Livesey, Clegg, Bradford Colliery, Manchester, *Hon. Auditor.*
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 6, De Grey Road, Leeds.
1891	Marshall, Herbert S., The Larches, Wigan.
1892	Mathews, D. H. F., H.M. Inspector of Mines, Newton-le-Willows.
1881	McAlpine, G. W., Parkside, Accrington.
1890	McGeevor, James, Garswood Hall Colliery, Wigan.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1883	Mather, William Penn, Iron Works, Salford.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester.
1890	Mercier, Maunsell, King Street, Wigan.
1892	Miller, Arthur, 65, Newton Street, Hyde.
1892	Mills, David, Bradford Street, Farnworth.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgefield, Manchester.
1892	Morris, Moses, Swan Lane, Hindley, Wigan.
1890	Morris, Thomas, Rosebridge Collieries, Wigan.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1888	Munro, Donald, Fairfield, near Manchester.
1878	Nall, Simon, Newbold, Rochdale.
1885	Newton, Charles Edward, C.E., F.G.S., Carlton Buildings, Cooper Street, Manchester.
1878	Nelson, William, Abram Colliery, Bickershaw, near Wigan.

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Year of Election.	
1888	Oliver, Samuel A., King Street, Wigan.
1891	Orchard, Albert J. A., Atherton Collieries, Atherton, near Manchester.
1838	Ormerod, H. M., F.G.S., 5. Clarence Street, Manchester. *Hon. Treasurer and Past-President.*
1874	*Owen, Sir Richard,* D.C.L., F.R.S., Sheen Lodge, Richmond Park, London, S.W.
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles. *Member of Council.*
1877	Peace, Maskell W., F.G.S., 18, King Street, Wigan. *President.*
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester. *Hon. Auditor.*
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Rhosneigr, Ty Croes, R.S.O., Anglesea.
1877	Platt, Samuel Sydney, Assoc.M.Inst.C.E., 14, King Street South, Rochdale.
1891	Prestwich, Joseph, Irwell Park, Eccles.
1860	Ridyard, John, F.G.S., Hilton Bank, Little Hulton, Bolton. *Member of Council.*
1889	Robinson, John, Haydock Collieries, St. Helens.

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Year of Election.	
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1890	Robson, Thomas, Wigan and Whiston Colliery Co., Prescot.
1891	Roeder, Charles, Ernsee Cottage, Amhurst Street, Fallowfield, Manchester.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *Vice-President.*
1888	Scarborough, George Edward, Colliery Manager, New Town and Meadows Collieries, Wigan.
1887	Scott, Frederic W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, Redthorpe, Tonge, Bolton.
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Madeley Coal & Iron Co., Limited, Madeley, near Newcastle, Staffordshire.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1889	Settle, William, Snow Hill, Darcy Lever, near Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1877	Shuttleworth, Sir Ughtred J. Kay, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1884	* Simpson, W. W., Winkley, near Whalley, Blackburn.
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	* Smethurst, William, F.G.S.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	* Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.

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Year of Election.	
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1866	Speakman, Harry, Bedford Collieries, Leigh, Lancashire. *Member of Council.*
1880	Speakman, John, The Walmsleys, Leigh, near Manchester,
1881	Squire, J. B., A.Inst.C.E., 297, Clapham Road, London, S.W.
1890	Stafford, Thomas, 1, Lea Road, Heaton Chapel, Stockport.
1859	Statter, Thomas, Stand Hall, Bury.
	Stechert, G. E., 30, Wellington Street, Strand, London, W.C.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road. Bowdon. *Hon. Secretary.*
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, 134, Cemetery Road, Barnsley.
1881	Taylor, Alfred, 35, St. John's Road, Dudley.
1889	Taylor, John, Great Harwood Collieries, near Blackburn.
1889	Taylor, William, Rock Villa, Hoddlesden, Darwen.
1892	Thompson, James, Westhoughton, Bolton.
1884	Toman, Daniel. Messrs. Blundell, Pemberton Colliery, Wigan.
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Ash Grove, 368, St. Helens Road, Daubhill, near Bolton. *Past-President.*
1891	Tonge, Alfred J., Ash Grove, 368, St. Helens Road, Daubhill, near Bolton.
1886	* Trafford, Sir Humphrey Francis de, Bart., Trafford Park, Manchester.

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Year of Election.	
1892	Turner William, Wigan Junction Colliery, Abram, near Wigan.
. 876	Unsworth, John, Scot Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1888	* Walmsley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1892	Ward, Alexander Haustonne, Coppull, Chorley, Lancashire.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich.
1880	Watts, William, F.G.S., Piethorne, Rochdale. *Member of Council.*
1890	Webster, Alfred E., Wigan Coal and Iron Co., Ltd., Wigan.
1878	Wells, Samuel B., General Manager Bengal Coal Co., Limited, Ranigunj, India.
1877	West, T. E., Union Street, Oldham.
1890	*Whitaker, William*, B.A., F.R.S., F.G.S., 33, East Park Terrace, Southampton.
1891	Whitehead, J. J., Duxbury Park Colliery, Chorley, Lancashire.
1867	Wild, George, Albert Street, Bardsley, Ashton-under-Lyne. *Member of Council.*
1880	Williams, E. Leader, M.Inst.C.E., Manchester Ship Canal Company, King Street, Manchester.

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Year of Election.	
1886	*Williamson, Professor W. C.*, LL.D., F.R.S., 43, Elms Road, Clapham Common S., London.
1876	Winstanley, Robert, 28, Deansgate, Manchester. *Vice-President.*
1886	* Wood, Guy.
1876	Woodward, H. A., Oakwood, Clifton, near Manchester. *Member of Council.*

Members are requested to communicate to the Hon. Secretary all changes of address, also any corrections or omissions in the list.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XXII. SESSION 1892-93.

THE ORDINARY MEETING of the Members was held on Tuesday, November 8th, 1892, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society :—

Mr. ARTHUR T. HOLDEN, Solicitor, 20, Mawdsley Street, Bolton.

Mr. ALEXANDER C. BOYD, The Lakes, Dukinfield.

Mr. JOHN THOM, Canal Works, Patricroft.

ILLNESS OF THE PRESIDENT.

The Hon. Secretary (Mr. STIRRUP) said that, as many of the members were aware, a letter had been received from the President, Mr. Maskell William Peace, saying, that in consequence of ill health he had been ordered by his medical

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adviser to take a journey to the South of Europe. Mr. Peace, not feeling justified under these circumstances in retaining his position as President, had sent in his resignation of the office. The resignation was brought before a special meeting of the Council a few days ago, when it was unanimously resolved not to accept it, as the Council considered that the President's contemplated sojourn in the South would re-establish his health, and that the Society would have the benefit of his presidency later in the session.

In reply to this resolution of the Council, Mr. Peace had written thanking the Council and members for their kind consideration, and saying that he hoped on his return to bring back with him the materials for the address which it had been his wish to give them to-day.

THE TIME OF MEETING.

Mr. Stirrup said that it was perhaps desirable that he should now report the result of the effort which had been made to ascertain the feeling of the members with regard to the time of meeting. Post cards for reply had been sent out asking the members to say what day and hour, in their opinion, would be most convenient. About 180 cards were sent out, and 62 were returned. That showed that 28 were in favour of the present arrangement, and several with slight alterations of the hour. The rest—those who did not reply at all—must be supposed to be indifferent, and agree with it also.

Mr. Munro: No, no.

The Chairman: They were, I suppose, neutral.

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Mr. Stirrup: If they disapproved of the present arrangement, why did they not answer? We cannot tell their views on a matter of this kind unless they reply to the questions on the card. At any rate, of the replies sent in, 28 were in favour of the present arrangement; several others approved of the day, but differed as to the hour of meeting.

Mr. Winstanley read a summarised statement of the replies and said, that of the members who replied, 28 were in favour of the existing arrangement; four replied "No preference"; three were for meeting at 3-30 on the Tuesday; five for meeting at 4-0; one for meeting at 4-30; four for meeting at 5-0; two for meeting at 7-0; one for the third Tuesday in the month at 3-0; and six for meeting after 6 p.m.

Mr. Munro: This is a question that concerns the active members of the Society, and it is one on which the non-active members should hardly have been asked to vote. I think there can be no doubt that a majority of the active members would favour a change. There are only 28 members who you can really say are in favour of the present arrangement. Three o'clock on a Tuesday afternoon is a most inconvenient time; it is the busiest part of the day, and business men cannot possibly attend. I am sure some of those now present are feeling the inconvenience. There are gentlemen who would become members of the Society if the hour of meeting were altered: they say that a meeting at 3 o'clock breaks into business and practically spoils the day.

Mr. Stirrup: What are we to do in order to ascertain the the opinions of the members? I put it as plainly as I could in the circular.

Mr. Munro: You did, I am sure the Hon. Secretary has

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done all he could with business-like promptitude, and personally, I am indebted to him for it. At the same time I am one who could not attend often, if at all, at 3 o'clock in the afternoon.

Mr. STIRRUP: It is clear we cannot fix a time that will suit everyone.

Mr. MUNRO: Yes; but you had 62 replies, and 32 of those are evidently against the present hour.

Mr. WINSTANLEY: That is scarcely so. There are 28 absolutely in favour of the present arrangement; four have no preference, and 16 are for the same day with slight variations of the hour; whilst six want it after 6 o'clock.

Mr. MUNRO: It is rather curious that several now in the room, including Mr. Winstanley himself, have *this afternoon* declared to me against the hour of meeting!

Mr. WINSTANLEY: Half an hour or an hour later would certainly suit me better, but it would be almost impossible to fix a time convenient to every one. We ought, therefore, to try and accommodate the majority.

Mr. STIRRUP: It has been suggested at the Council meeting that we should have two evening meetings in addition to the ordinary meetings, which might possibly meet the views of some of the members.

Mr. DE RANCE: I may say that since you did me the honour of electing me an honorary member, now a good many years ago, I have never failed in any one year to give you a paper; and I must say that everyone of those papers has been given at the greatest inconvenience to me, as regards time. I can confirm what a gentleman on my left (Mr. Munro) has said. I know numerous persons who are engaged in business in this district who would join the

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Society only for the inconvenient hour of meeting—three o'clock—the very time when they are most busy.

The CHAIRMAN: Perhaps I might suggest that, as Mr. Munro takes an active interest in this question he might go into it further and ascertain the prevalent feeling as to an alteration, and, if thought desirable, to what day and hour.

Mr. MUNRO said he would act upon the suggestion.

The CHAIRMAN: I can assure Mr. Munro that there is no personal feeling in regard to this matter on the part of members of the Council. Their only desire is to fix a time which shall be most convenient to the general body of the members. Has any member any new facts of interest to bring before us, before we proceed to the business of the day? Mr. De Rance, have you anything to tell us?

THE GLACIAL DRIFTS.

Mr. DE RANCE said: During part of the past season I have been engaged in surveying the western slopes and valleys of the Pennine Chain, to the east of Macclesfield and Congleton, a district of great interest as regards its glacial phenomena. My previous work in Lancashire and Cheshire, extending over more than 1,200 square miles, had given me no opportunity of studying the relations of the drift area to the west, to the driftless area to the east, and the district now examined gives, in my opinion, a key to the solution of that problem. In 1869, I wrote an article in *The Geological Magazine*, expressing my views on Glacial matters, and subsequently in the Geological Survey Memoir, "On the Superficial Geology of South-West Lancashire," published in 1877, I again stated that I considered

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that *land ice* had covered the whole of Lancashire up to a certain level, but subsequently the country subsided, and most of the Glacial Drift was deposited under submarine conditions. In so reading the country, I followed the views given to me as authoritative when I first visited the country in 1868. Recently, my duties have led me to areas where not only these Glacial Drifts thinned off, but where they are entirely absent, and I have had the opportunity of carefully studying the relations of the drift at these high elevations, and the good fortune to discuss the conditions there obtaining with the Rev. Professor Wright, of Oberlin College, U. S., at Cardiff, and subsequently on the ground, just before his return to America, which resulted in my making up my mind to neither write, nor speak, as regards any definite views on the Glacial Drift question, until I had further studied the question, with the new lights, on the ground on which I was engaged, for, as regards previous observations, I can endorse a remark I heard made, by an eminent Q.C., before a Parliamentary Committee, "that the eye only sees what the brain looks for!" Since Dr. Wright's visit to Macclesfield in August of last year, I have continuously pondered over and studied these matters, with an entirely open mind, and now, I admit with very great reluctance, I feel it my duty to tell you, that though the late Professor Carvill Lewis may have been in extreme in some of the views he held, as regards his application of the results of his studies, in the United States, to the phenomena observable in Britain, I believe, in the main, he was right, and I feel profound regret that I did not realise it when he addressed the British Association at Birmingham, and I must confess that I did not see the force and weight of the evidence he adduced until I read and carefully studied Dr. Wright's "Ice Age in America," since which my eyes have been opened, and I realise the true significance of finding fragments of sea shells

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up to 1,280, and granites from the South-West of Scotland, and 7ft. boulders of Andesites from the Lake District at 1,330 feet. Much light is thrown on the glacial question by careful study of the new one-inch Ordnance Map—in which the 1,250 feet contour is engraved (which, curiously enough, is omitted on the six-inch map), and which is of great importance as regards glacial matters. Westward of the Pennine axis, the Glacial Drift rises to this level, or somewhat above it—in both Lancashire and Cheshire, eastward, though lower elevations may occur, the drift is conspicuous by its absence. Gravel and sand mounds constantly occur with shell fragments, but perfect shells are rare, and the two valves of bivalves united are invariably absent, and when fragments of shells can be identified, they are found to belong to species which indicate that they did not all live in water of the same depth, all of which is very much against the idea of their being deposited in the sea or thrown upon a beach. More than that, some of them are indicative of a warmer climate than at present obtains. Apparently they have been caught up on the sea bottom from deposits of various ages, and forced inland and deposited at various elevations. Apart from this, you have the remarkable fact that a few miles east of where these high level drifts occur, in the Buxton district, you have an extensive area below the 1,250 feet contour where not a trace is found of any glaciation, and not a fragment of Buttermere granite, though thousands of tons of Buttermere granite are spread over Cheshire. Again, in some of these upland valleys, 600 or 700 feet in depth, you get the drift on one side but not on the other; and the only explanation of this, appears to me, is that the deposits could not have been left by water. If water had deposited these drifts, they would have filled up the valleys. As I said before, I have come to these conclusions with reluctance. I now believe that I

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am in the presence of *facts* on the one side, against *theories* based on views of others, on the other, and I feel it my duty at the earliest opportunity, to state the conclusions I have arrived at, now that my mind is made up; and I thank you, Mr. Chairman, for giving me the opportunity of stating the views I at present hold.

The CHAIRMAN: Whilst Mr. De Rance is here, I should like to ask him whether he feels at liberty to give us any explanation of the change which it is said is being made by the Geological Survey in the arrangement of the Trias—doing away with the arrangement of Sir Roderick Murchison?

Mr. DE RANCE: I am placed in a somewhat difficult position by your question. I cannot give any information as an officer of the Government Geological Survey, but speaking as a private individual, I should say that from all I have seen of the geology of Cumberland, I should have thought that which Sir Roderick Murchison, Professor Sedgwick, and those associated with them did, was perfectly correct, and I regard the re-classification which I understand has taken place in relegating the St. Bees Sandstone —what was formerly regarded as of Permian age—to the Trias, with great regret. I think no change has been made elsewhere in the subdivision of the Trias by the Survey.

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DISCOVERY OF A LARGE BOULDER AT ARDWICK.*

Mr. Mark Stirrup: I am pleased to see Mr. De Rance here to-day as he is a member of the Boulder Committee of the British Association, and also the President of the Glacialists' Association, and that he has had an opportunity of relieving his mind and recanting some of his published opinions on glacial matters.

I think glacialists, should, of all persons, be allowed to change their opinions, and I have no doubt many of us will see reason to do the same with regard to the many intricate problems which still surround the history of the drift deposits.

My purpose in rising now is not to discuss this subject but to report the finding of a giant boulder at Ardwick, which has been disclosed by an excavation now being made near Chesters' Brewery, off Chancery Lane, Ardwick.

This erratic at present lies on its bed of stiff boulder clay by which it was surrounded and covered at a few feet from the surface of the ground, and the direction of its longest axis is east and west, magnetic.

Its approximate measurements are 7 feet 5 inches in the longest diameter, its breadth in the widest part 4 feet 8 inches, and its depth at the most massive end, 3 feet 6 inches to 3 feet 7 inches. The estimated weight is about 17 tons.

* As some of the members may be able, from time to time, to impart information with regard to the occurrence of erratic boulders in the district, and also to assist the "Underground Water Committee of the British Association," the character of the information required will be found in the series of queries published as an Appendix at the end of this Part.—Ed.

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The shape of the block is roughly rhomboidal, tapering to slightly pyramidal form at thinner end, with angles well-rounded. It is an igneous rock, greenish in colour, fine grained, probably a diabase or dolerite.

Fine striæ or ice scratches, running parallel with the long diameter, are plainly visible on its smooth upper surface which when wet glistens in the sun. The sides are also smooth and striated.

One of its sides shows a scar from which a large fragment of the block has been broken, probably in its passage hither or when attached to the parent rock.

To account for this erratic in its present site, would seem to require, for its explanation, some change in the relative level of land and sea, whether it has been carried by a floe or coast ice, or by the agency of an iceberg. It is to be hoped that Mr. Chesters will see to its preservation, and the enclosure at Ardwick Green would seem to be the most appropriate spot.

Mr. Wild: One of the largest boulders I have ever seen was met with on the top of Chamber Hill, Broadway Lane, Oldham, nearly 670 feet above sea level, and I can only conclude that the district must have very greatly altered if it was brought up some ancient estuary and planted there.

Mr. Stirrup: Mr. De Rance tells us that he does not believe in any submergence, and there is our difficulty.

The Chairman: There is very little doubt that this subject is beset with difficulties, look at it from whatever point we may. I have long been of opinion that the easiest way of accounting for these large boulders was that the whole planetary system was formed at one time, and that it was simply the dragging of one planet over another which turned these things about, and the drift deposits took place

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then. But I have not been able to make any converts to that view. It is a thing which has not troubled me much; but still the glacial theory is beset with difficulties, and if members would set themselves to accumulate facts, instead of forming complete theories, I think we should be more likely to arrive at a satisfactory conclusion. There was a paper written by Sir Robert Ball, the Astronomer Royal, in which he attributed these deposits to an alteration in the distance of the moon. The tides, he argued, formerly rose very much higher, reaching, in fact, the levels at which we now find the drift deposits; but I do not find that many people have adopted his view either. However, if we set about accumulating facts, we shall perhaps get something which will supersede the glacial theory.

MR. R. ZEILLER ON THE FOSSIL PLANTS OF THE DOVER COAL.

(Translation by Mr. Mark Stirrup, F.G.S.)

Mr. Stirrup said: As the Society has taken a special interest in the boring and exploration for coal at Dover, a subject which has been brought before the members on two special occasions by Professor W. Boyd Dawkins, they would no doubt be interested by further particulars, which now came from a French source.

The following communication that I have the pleasure of translating appears in the Comptes Rendus of the Academy of Sciences of Paris, No. 17 (24th October, 1892,) the writer of which is Mr. R. Zeiller, the Palæontologist to the French Geological Survey.

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My object in bringing this "note" before the Society is not only for the interesting information which it contains of the fossils of the Dover coal beds—now first given to the public—but to show the appreciation and reliance which foreign geologists place upon palæontological evidence as a means of determining the succession of the rocks or the relative age of a coalfield. It was the latter fact, the value of the fossils of the coal measures in the determination of the age, and classification of the coal beds, the importance of which I am desirous of again impressing upon the members, seeing that the Society was now engaged in the long-neglected work of a systematic collection of the fossils of the Lancashire Coalfield :—

EXTRACT.

Comptes Rendus, 24th October, 1892.

"It is known that the boring undertaken at Dover by the Channel Tunnel Company, at the instigation and under the direction of Mr. Fr. Brady, Engineer to the Company, has reached the Coal Measures at 1157 feet in depth, and that there have been recognized ten beds of coal, of which eight beds measure more than a foot in thickness.

"These beds are almost exactly horizontal, which causes Mr. Brady to think that they are in the central portion of the basin. The coal of which they are formed contains, from an analysis which has been made by M. Watteyne, Chief Engineer of the Mines of Belgium, 25 per cent. of volatile matters, and resembles, by its composition, partly the fat coal of the Pas-de-Calais and partly those of Wales. In spite of the analogy of some of the sand-stones, met with in the boring, with those of the lowest region of the Belgian Coalfield, M. Watteyne repels the idea of their belonging to the base of the formation, because of the great richness of these coals in volatile matters; for his part Mr. Brady is inclined to see in the system traversed by the Dover boring, the equivalent of all or part of the upper division of the basin of Somerset, that is to say, the Farrington and Radstock beds.

"Nevertheless, the contents of a coal in volatile matters does not by any means establish an absolute criterion for the determination of

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the horizon, therefore these opinions can only be accepted under reserve until more ample information; but he was encouraged to hope that, among the vegetable impressions collected in the course of the boring, there would be some species met with capable of furnishing more precise indications on this important question.

"These plant impressions having been sent to me—thanks to the kind mediation of Mr. L. Breton, Engineer-Director of the Tunnel Works at Calais, and through the kindness of Mr. Brady—I have been able, in fact, to recognize among them some Ferns which are met with only at well-determined horizons of the Coal Measures, and which are, consequently, of a nature to solve the problem, or, at least, to narrow the solution of it to very strait limits.

"The levels, whence these impressions come, are those of 1894 feet below the surface, of 1900 feet, and of 2038 feet, the boring being continued, and having actually reached, according to what Mr. Brady has written me, the depth of 2100 feet.

"I have recognized the following species:—

"Level of 1894 feet. A fragment of Fern frond with serrate pinnules, nervation approaching the Odontopteroid type, that I am inclined to range in the genus *Mariopteris*, and which markedly resembles *Mar. sphenopteroides* LESQ. (sp.), without being able to attribute it positively to this species; the specimen is, in fact, too incomplete to be susceptible of precise determination.—*Neuropteris Scheuchzeri* HOFFM., represented by some large detached pinnules.—*Neur. rarinervis* BUMB., fragments of well characterized fronds.—*Neur. tenuifolia* SCHLOTH (sp.), portions of fronds.—*Lepidodendron aculeatum* STERNBG.; ramule identical with certain specimens from the Valenciennes basin.*—Besides, numerous heart-shaped seeds (*Cordaicarpus*), from 5mm. to 6mm. in height, with equal breadth, very analogous to *Cord. congruens* GR. EURY, but with striated surface; I should be disposed to class them with *Carpolithes corculum* STERNB.

"Level of 1900 feet. *Neuropteris Scheuchzeri.*—*Neur. rarinervis.*—*Neur. tenuifolia.*—*Cyclopteris*, fragment.—*Calamophyllites Gœpperti* ETTINGSH. (sp.); portion of articulated stem with very recognizable foliar scars.—*Lepidostrobus variabilis* LINDL. ET HUTT.—*Cordaicarpus* Cf. *corculum* STERNB. (sp.)

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* See figure: *Flore foss. du bass. Houiller de Valenciennes*, Plate LXV., fig. 6.

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"Level of 2038 feet. *Neuropteris Scheuchzeri;* fragment of pinnule a little doubtful.—*Lepidodendron lycopodioides* STERNB.; fragment of branch not well preserved.—*Stigmaria ficoides* STERNB. (sp.)

"All these species indicate the Coal Measures, but the majority do not allow more precise information. In fact, the *Calamophyllites, Lepidodendron, Lepidostrobus, Stigmaria,* that I have just cited, are met with almost indiscriminately through all the thickness of the Middle Coal, and in a part at least of the Upper Coal. The *Neuropteris tenuifolia* appears to be specially common in the Valenciennes basin in the highest zone, that of the fat coals of the Pas-de-Calais; but it is first met with, although rarely, at the base of the middle zone of the same basin; it cannot then serve as a basis for a determination of level.

"Fortunately, it is not the same with the *Neur. rarinervis* and *Neur. Scheuchzeri:* these, in fact, have been observed, in America as well as in Europe, only towards the top of the Middle Coal, or at the extreme bottom of the Upper Coal.

"In France they are plentiful in the upper zone of the Valenciennes basin, and they have only been met with below, quite at the top of the middle zone, and that only in one or two places.

"In our Upper Coal beds—that is to say, in the basins of the centre and of the south of France—they have not been, so far as I know, noticed anywhere, even at the lowest levels.

"In England they appear to be common in the Somerset basin, in the Radstock and Farrington beds, a little higher, as it seems, than our fat coals of the Pas-de-Calais, to judge of them by the perceptibly larger proportion of species of the Upper Coal that they contain.

"Likewise, in Yorkshire, they have only been met with above the middle of the Middle Coal Measures, and in Staffordshire the horizons at which they have been found in the Middle and Upper Coal Measures correspond either to our upper zone of Pas-de-Calais or to the little higher zone of Farrington and of Radstock.

"One may then infer, by the presence of these two species in the Dover boring, that, as Mr. Brady had presumed, the beds traversed by this boring belong to the upper region of the Middle Coal; and if one wished to put it more precisely, that they could not be more recent than the Radstock beds in Somerset, nor older than the deepest beds of the upper zone of the fat coals of the Pas-de-Calais."

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REPORT OF THE DELEGATE (MR. MARK STIRRUP, F.G.S.) TO THE MEETING OF THE BRITISH ASSOCIATION AT EDINBURGH, AUGUST, 1892.

At the meeting of the British Association, held at Edinburgh, in August last, I had the honour of being the representative of the Manchester Geological Society at the Corresponding Societies Conference, of which two meetings were held.

In submitting to your notice the list of committees appointed by the General Committee for scientific research in the various fields embraced by the Association's labours, I am requested to ask not only the Society in its corporate capacity, but your individual aid, when practicable, in carrying out their objects. The majority of these committees deal with mathematical and physical questions, also with biological and natural history studies, which lie outside of our province; yet, from time to time, opportunities may arise on the part of some of you to assist with information such long-standing committees as those for collecting information on "The Rate of Increase of Underground Temperature in Land and Water," "The Circulation of Underground Waters in the Permeable Formations of England," "The Erratic Blocks Committee, &c.," and I hope those opportunities will not be lost sight of by the members.

The Chairman, Professor Meldola, F.R.S., in welcoming the delegates to the Seventh Conference, complimented them on the position which the Corresponding Societies held in relation to the Association, and the good work that had been done.

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The Chairman then introduced the various subjects which fall under the supervision of the several sections of the Association, and invited remarks thereon.

Meteorological Photography and Temperature Variations in Lakes, Rivers, and Estuaries were touched upon, but as the contribution of our Society to the latter subject in the work of Mr. William Watts, F.G.S., had been concluded, no necessity for remarks by your delegate were required.

Under Section C the work of the Underground Waters Committee, and that of Erratic Boulders was introduced by Mr. De Rance, F.G.S., who claimed the assistance of local Societies in these investigations.

With regard to underground waters, the Vice-Chairman, Mr. G. J. Symons, F.R.S., suggested that when wells were being sunk, the temperature of the water as well as the depth should be recorded, and that it would be valuable information to have the seasonal variation of depth in underground waters, and wherever practicable daily observations of temperature, which should be taken always at the same hour of the day.

Mr. William Watts spoke upon the denundation of high-lying drainage areas, such as those of Millstone Grit to the north of Manchester, and referred to the amount of material brought down by flood waters into the wreck lodges of waterworks reservoirs. He thought such observations could be profitably extended to other districts, in order to collect information as to the degree of protection afforded by heather, grass, and peat to the sub-soil.

The activity of various societies, in the collection of photographs of geological interest, was visible in the large display of photographs gathered from various parts of the kingdom, showing remarkable rock formations and the

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effects of foliation, faulting, and erosion. This is a popular branch of work, which probably several of our members could aid, and I shall be pleased to furnish any particulars to those interested in photography.

A large part of the time of the Conference was taken up with the discussion of the questions of the "Disappearance of Native Plants" and the "Destruction of Wild Birds' Eggs," and the means to be adopted for their preservation, but as these subjects more immediately concern societies devoted to the study of Natural History, I need not refer to them further.

The assistance of the corresponding Societies is sought in a proposed organisation of an Ethnological Survey of the United Kingdom, to which end a special circular has been addressed to each of the delegates.

The enquiry will include family and racial characteristics, ancient customs, local forms of speech, peculiarities of language, such as obtain or have been prevalent among the older people in isolated districts, and which are now rapidly vanishing from amongst us owing to the general spread of education and increased facilities of communication by road and rail.

As interesting results are expected to proceed from this survey, I should be glad to have the name of any member or friend able to assist, so as to forward it to the Secretary of the Special Committee, who would send instructions as to the line of enquiry to be adopted.

Having given you a sketch of the principal matters brought under the notice of the delegates at the Conference, I propose now, as on previous occasiens, to briefly notice some of the papers of more general interest, which were brought before the Section devoted to Geology, and to which I was specially attached as your representative.

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The presidential address of Sir Archibald Geikie, Director-General of the Geological Survey, was naturally tinged with the "*genius loci*," and referred at large to that now famous "Theory of the Earth," by Dr. Hutton, which had its birth in Edinburgh more than a hundred years ago, and which was afterwards elaborated and explained in the "Illustrations of the Huttonian Theory" by his friend Professor Playfair.

Hutton and Playfair clearly saw that it was in the operations of nature taking place before their eyes, that an explanation of the past history of the earth must be sought. They boldly enunciated the law, that the stratified formations are due to the waste of pre-existing lands which had not always presented the same features as the present surface of the earth.

The President, while noting that Hutton and Playfair belonged to what is known as the Catastrophic School, did not omit to mention that it was by proceeding on the same lines—the observation of the physical agencies affecting the surface of the earth, and a more intimate acquaintance with the structure of the rocks—that their successors sought to establish their well grounded faith in the higher verities of the Uniformitarian doctrines, so well expounded by their great apostle, Lyell. "Among the debts which science owes to the Huttonian School," said Sir Archibald Geikie, "not the least memorable is the promulgation of the first well founded conceptions of the high antiquity of the globe," and, proceeding to sketch the origin of scenery, he said, "the law of evolution is written as legibly on the landscape of the earth, as on any other page of the Book of Nature."

Professor Lapworth's address as the President of the Geological Section, referred also to the history and influence of the doctrines of Hutton, and to the mutual

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help of Geology and Biology in illustrating the succession of the rocks and the sequence of organic life.

Passing from these considerations, he went on to speak of what he called the "New Geology," those obscurer pages in the earth's history, the causes of elevation and depression of large tracts of the earth's surface.

Professor Heim's "Mechanismus der Gebirgsbildung" was laid under contribution as giving us the clue to the laws which rule in mountain building and in the bending and folding of the rocky formations of the earth's crust.

The examples of the simple Earth Fold, consisting of arch and trough, which is illustrated in the phenomena of mountain ranges, Professor Lapworth extended to the consideration not only of the great orographic features of Continents, but to those great depressions of the earth's surface occupied by its seas.

The geographical surface of North America with its two great mountain ranges of the Rockies and the Alleghanies, when considered as a whole, he took as representing a double arch with a sag or common trough in the middle, and that this double arch was to be regarded as the natural complement of the equally double Atlantic trough.

After referring to various examples of the Earth Fold, the Professor went on to say "that even if we restrict our observations to the most simple and elementary conceptions of the rock fold as being made up of arch-limb, trough-limb, and twisting, but still continuous septum, we are able to connect, in one unbroken chain of causation, the minutest wrinkle, from the finest lamina of a geological formation with the grandest geographical phenomena of the face of our globe."

"We find precisely as we anticipated that the wave-like surface of the earth of the present day reflects in its entirety the wave-like arrangement of the geological formations

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below. On the land we find the surface arches and troughs answer precisely to the grander regional anticlines and synclines of the subterranean sedimentary sequence; and it may, I believe, be regarded as certain that the submarine undulations have a similar relationship. We find in the new geology, as Hutton found in the old, that geography and geology are one. We find, as we suspected, that the physiognomy of the face of our globe is an unerring index of the solid personality beneath. It bears in its lineaments the characteristic family features and the common traits of its long line of geological ancestry."

With regard to the papers presented to the Section, they included the usual reports of Special Committees and a full number devoted to local and Scottish geology, with others dealing with particular branches of petrology and palœontology, all indicating a wide-spread interest in the many problems presented to workers in geology and its allied sciences.

Possibly, none of these papers calls for any special remark from me, yet there was one on some Reptile remains from the Elgin Sandstone, by E. T. Newton, F.G.S., which seemed to me to offer an instructive lesson both to the geologist and palæontologist, illustrated as it was by specimens most laboriously and successfully developed. Sandstones, differing much in geological age, present features so similar as to be often misconstrued, as the lithological characters often offer no means of determination.

You are well aware how difficult it is in our own neighbourhood to discriminate Permian from Triassic Sandstones, and the same thing obtains in the case of the Old Red and the Triassic.

We have then perforce recourse to the stratigraphical position of the rock or its contained organisms to give us a clue to its geological age.

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These Elgin Sandstones, for similar reasons, have given rise to much controversy as to their exact position in the geological scale.

Murchison and Sedgwick decided on stratigraphical grounds that they belonged to the Old Red, and its fossil fishes supported this view.

Later discoveries, however, of certain reptilian remains in them, have induced palæontologists to regard them as of Triassic age, a view supported by Professor Huxley.

The occurrence of reptiles with Old Red fishes like *Holoptychius* in the same quarry is, I believe, a unique fact, and recourse has been had for an explanation to some concealed faulting or unconformity. However, that may be, probably further evidence will in time be forthcoming. It was not, however, to draw your attention to the apparently antagonistic claims of stratigraphy and palæontology in deciding the age of these rocks, that I mention these facts, but rather to point out the remarkable way in which the palæontological evidence has been preserved to us.

When you consider that in most cases not a fragment of the original animal has been preserved, that all the solid parts or bones have been dissolved away, it would seem impossible that any life-like restoration of the organism would be forthcoming, yet such is the fact. The explanation is, that all the reptile remains occur as hollow cavities, from which casts have been obtained by filling in with a suitable material. The blocks, when brought from the quarry, were more or less split open or broken, often necessitating the casts to be made in several parts which were afterwards fitted together. The time and labour involved in this task has been rewarded by the restoration of skulls and parts of skeletons of several *Dicynodonts* and one or two other remarkable forms of reptiles. The most astonishing of these reptilian restorations was one, whose

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skull about 6 inches in length, was covered upon the face and cheeks with a defensive armour of horns, some thirty in number, varying from a fourth of an inch to nearly 3 inches in length. These interesting results have been obtained by the careful and skilful use of what, at first sight, might be considered as most unpromising material.

Having thus confined myself more particularly to the consideration of the geological subjects submitted to the meeting of the British Association at Edinburgh, and while I can speak of no startling discoveries or brilliant speculations enunciated there, yet, I think, a candid enquirer will allow, that a solid accession of knowledge has been garnered, which will relieve the meeting from the charge of either dullness or decay.

GLOBULAR CONCRETIONS FROM THE COAL MEASURES OF LANCASHIRE.

Exhibited by Messrs. CLAY, STIRRUP, and WILD.

Mr. G. WILD said that the globular concretions which he had laid on the table were from the Coal Measures at Bardsley Colliery, near Ashton-under-Lyne. He had, he said, no theory as to their origin. In form they bore a great similarity to one another, and were always found lying like an inverted top or with a contorted or spiral protuberance (which seemed to characterise most of them) on the upper side. In some cases they had been broken in two and diplaced a little where they had lain, at the the joint of a rock; and the pieces having parted, the intervening space had been filled with carbonate of lime. The fracture of the nodule had taken place after it had become hardened, and had subsequently been cemented by an infiltration of lime.

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Mr. STIRRUP exhibited, among others, a concretion obtained from a cutting near Diggle, on the Manchester and Huddersfield Railway, which was remarkable for its smooth exterior and its regular spheroidal shape.

Mr. CLAY had sent some others, orbicular in outline, but flattened or compressed, which were obtained from the Astley Pit, Dukinfield, and he (Mr. Stirrup) had hoped that Mr. Clay would have been present to have said something about them.

Mr. STIRRUP went on to say that concretions were common in the Coal Measure rocks as in many other of the stratified deposits, but difficulties arose in explaining their mode of origin and curious shapes. What we know is, that there is a tendency in, or property of, matter to influence or dispose elements of like composition to flock together, thus any mineral diffused in a state of minute division through a mass of different nature to itself seems to have a tendency and a capability of separating itself from the mass, this is, I think, exemplified in the concretions which Mr. Wild exhibits, which have segregated from a clayey matrix, but are evidently calcareous, as they effervesce strongly with application of acid.

This property of matter is well seen in iron ores and ironstone concretions, the concreting action commencing often around some fossil organism as a nucleus.

Perhaps this action of segregation of like particles of matter may be best illustrated by the following extract taken from Monograph XI. of United States Geological Survey—Geological History of Lake Lahontan—where the formation of clay concretions around a nucleus of small shells is cited:—

"The manner in which concretions of this nature are formed was shown in a very interesting manner a few years ago during the process of the work of filling in the so-called Potomac flats, on the river front at Washington, district of Columbia.

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"For the double purpose of raising the flats and deepening the channel gigantic pumps were employed, which raised the sediment from the river bottom in the form of a very thin mud, and forced it through iron pipes to the flats, where it flowed out, spreading quietly over the surface.

"The material of this mud was mainly fine siliceous sand and clay intermingled with occasional fresh-water shells and plant *débris*. As this mud flowed quietly from the mouth of the pipe and spread out over the surface, the clayey particles began immediately to separate from the siliceous sand in the form of concreting balls, and in the course of a few minutes these would grow to be several inches in diameter. Such, owing to the rapidity of their formation, contained a large amount of sand and shells, though clayey matter predominated."

The CHAIRMAN inquired if Mr. Wild's specimens were taken from the flagstone bed, lying below the Rough Rock coal.

Mr. WILD: They are from our sinking at Bardsley, 14 or 15 yards below the new mine.

The CHAIRMAN: They are commonly found in the flagstones which are so extensively worked in Rossendale.

Mr. W. S. GRESLEY's reply to a discussion on his paper, "A typical section of the 'Main Coal' of Leicestershire," was postponed until the next meeting, owing to the lateness of the hour.

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APPENDIX.

THE GLACIALISTS' ASSOCIATION.

President: C. E. De Rance, F.G.S.

Secretary: Percy Kendall, F.G.S.

(*A.*) ISOLATED BOULDERS.

1. What is the name of the Parish, Estate, and Farm, on which Boulder is situated, adding nearest Town, and County, and any particular enabling its position to be marked on the Ordnance Map?

2. What are dimensions of Boulder, in length, breadth, and height, above ground?

3. Is the Boulder rounded, subangular, or angular?

4. If the Boulder is long-shaped, and has not been moved by man, what is direction by compass of its longest axis?

5. If there are any natural ruts, groovings, or striations on Boulder, state—

(*a*) Their length, depth, and number.

(*b*) The part of Boulder striated, viz., whether top or sides.

(*c*) Whether the striations are in the direction of the longer axis, or at what angle to it?

(*d*) Whether there is any difference of direction between the scratches on the upper surface and those on the lower surface? Give the compass bearing.

(*e*) Whether there are any indications by which you can tell from which direction the several sets of scratches were inflicted?

[*The scratches on the under side are commonly from the opposite direction to those on the upper surface, though parallel to them.*]

6. What is the nature of the rock composing the Boulder? If it is of a species of rock differing from any rocks adjoining it, state locality where, from personal observation, you know that a rock of the same nature as the Boulder occurs, the distance of that locality, and its bearings by compass from the Boulder.

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7. If the Boulder is known by any popular name, or has any legend connected with it, mention it.

8. What is the height of the Boulder above the sea?

9. Is the Boulder indicated on any map, or does it make any boundary of a County, Parish, or Estate?

10. If there is any photograph or sketch of the Boulder, please to say how the Committee can obtain it?

11. Is the Boulder connected with any long ridges of gravel or sand, or is it isolated?

12. Upon what does the Boulder rest?

(*B.*) GROUPS OF BOULDERS.

1. What is the name of the Parish, Estate, and Farm on which they are situated, adding the nearest Town and County, and any particular enabling their position to be marked on the Ordnance map?

2. What are the dimensions of the smallest and largest Boulders of the group?

3. Are the Boulders rounded, subangular, or angular?

4. If any large Boulder of the group (which has not been moved by man) is long-shaped, what is the direction by compass of its longest axis?

5. If there are any natural ruts, groovings, or striations on any Boulder, state—

(*a*) Their lengths, depth, and number.

(*b*) The parts of the Boulder striated, viz., whether top or sides.

(*c*) Whether the striations are in the direction of the longer axis, or at what angle to it?

(*d*) Whether there is any difference of direction between the scratches on the upper surface and those on the lower surface? Give the compass bearing.

(*e*) Whether there are any indications by which you can tell from which direction the several sets of scratches were inflicted?

[*The scratches on the under side are commonly from the opposite direction to those on the upper surface, though parallel to them.*]

6. State—

(*a*) Localities where rocks undoubtedly of the same nature as the Boulders occur.

[*Be careful to ascertain that none of the Boulders have been brought from a distance by human agency.*]

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(*b*) The distance of those localities and their bearings by compass from the Boulders.

7. What is the nature of the rocks composing the Boulders, and in what proportions do the Boulders of the various rocks represented in the ground occur?

8. What is the height of the group above the sea?

9. Over what area does the group extend, and what number of Boulders are there in the group or per acre?

NOTE.—With respect both to the isolated Boulders and the groups of Boulders described, state whether they are exposed on the surface or surrounded by any deposit. Describe the nature of any deposit containing Boulders, and state whether the imbedded Boulders are of the same character as those (if any) upon the surface.

UNDERGROUND WATER COMMITTEE.

Secretary: C. E. DE RANCE, F.G.S.

Replies are desired to as many of the following queries as possible:—

1. *Position* of well or shafts with which you are acquainted?

1*a*. State *date* at which the well or shaft was originally sunk. Has it been deepened since by sinking or boring? and when?

2. Approximate *height* of the surface of the ground above Ordnance Datum (mean sea level)?

3. *Depth* from surface to bottom of shaft or well, with diameter. *Depth* from surface to bottom of bore-hole, with diameter?

3*a*. *Depth* from the surface to the horizontal drift-ways, if any? What is their length and number?

4. *Height* below the surface, at which water stands *before* and *after* pumping. Number of hours elapsing before ordinary level is restored after pumping?

4*a*. *Height* below the surface, at which the water stood when the well was first sunk, and height at which it stands now when not pumped?

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5. *Quantity* capable of being pumped in gallons per day of 24 hours? Average quantity daily pumped?

6. Does the *water level* vary at different seasons of the year, and to what extent? Has it diminished during the last ten years?

7. Is the ordinary *water level* ever affected by local rains, and if so, in how short a time? And how does it stand in regard to the level of the water in the neighbouring streams, or sea?

8. *Analysis* of the water, if any. Does the water possess any marked *peculiarity?*

9. *Section* with nature of the rock passed through, including cover of drift, if any, with *thickness?*

9*a*. In which of the above rocks were springs of water intercepted?

10. Does the cover of Drift over the rock contain *surface springs?*

11. If so, are these *land springs* kept entirely *out* of the well?

12. Are any large *faults* known to exist close to the well?

13. Were any *brine springs* passed through in making the well?

14. Are there any *salt springs* in the neighbourhood?

15. Have any wells or borings been discontinued in your neighbourhood in consequence of the water being more or less *brackish?* If so, please give section in reply to query No. 9.

16. Kindly give any further information you can.

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APR 12 1893

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XXII. SESSION 1892-93.

THE ORDINARY MEETING of the Members was held on Tuesday, December 13th, 1892, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

WILLIAM SAINT, Esq., H.M.I.M. Vice-President, in the Chair.

NEW MEMBERS.

The following gentlemen having been duly nominated were balloted for, and unanimously elected Ordinary Members of the Society:—

JAMES HALLIWELL, Manager, Duxbury Park Colliery, Chorley, Lancashire.

THOMAS WARBURTON, 10, Bolton Road, Moses Gate, Bolton.

W. W. MILLINGTON, Manager, Chamber Colliery Company.

FREDERICK JOHN GRANT, Bank Field, Burnley.

THE LATE PRESIDENT.

Mr. STIRRUP, Hon. Secretary, stated that the Council at its last meeting passed a vote of condolence with the widow and relatives of Mr. Maskell W. Peace, who had died since his election as President of the Society at its annual meeting in October. The resolution passed was as follows:—

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"That the Council of the Manchester Geological Society, while regretting the loss which the Society has sustained by the decease of its much valued member and esteemed President, desire to offer their sincere sympathy and condolence with Mrs. Peace and the family in their sudden bereavement."

In acknowledgment of the resolution the following letter had been received from Mr. Charles O. Peace:—

Lynwood, 42, Park Avenue,
Southport, *30th November, 1892.*

Dear Sir,

Mr. Ellis has forwarded on to me the very kind resolution which has been passed by the Council of the Manchester Geological Society with reference to my late brother.

Will you kindly convey to the members of the Council, on behalf of Mrs. Peace, myself, and the other members of the family, our sincere thanks for their kind expressions of sympathy and condolence.

Believe me,
Faithfully yours,
CHARLES O. PEACE.

MARK STIRRUP, Esq., Manchester Geological Society,
36, George Street, Manchester.

A TYPICAL SECTION OF THE "MAIN" COAL OF THE MOIRA DIVISION OF THE LEICESTERSHIRE COALFIELD.

Reply to Discussion (Part XVIII., Vol. XXI.)

BY THE AUTHOR, MR. W. S. GRESLEY, F.G.S.

The author begs to thank the members of the Society for their reception of his paper and criticism thereon. He would like to be allowed to make one or two short observations in reply to the discussion.

On page 552 of Transactions, the Hon. Secretary (Mr. Stirrup) makes it appear that I report the occurrence in the "main coal" bed of *fish remains.* The references to

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such remains in the paper are to be found at top of Section "B," on plate facing page 522; on page 525, where I said "There are several 'fish beds' in the series;" the word *series* relating, of course, to the whole of the Coal Measures in the district as a group, and not to the strata comprising the "main coal" seam; and, thirdly, on page 532, in layer numbered "87," where the *possible indications* of fish are recorded. The nearest unmistakable fish remains to this coal bed that I know of are those in the blue shale which forms the roof of the "Big Rider" coal ("5" of Columnar Section "B"). Though carefully looked for, I cannot say that I ever detected *bona fide* fish remains in this particular coal—the "main" seam.

Replying to Mr. Wild's "point" number "4" (page 553), which has direct reference to *Stigmaria*, I wish to say that reliable authorities on fossil botany tell me the *structure* of *Stigmaria* allows it to be classed as an aquatic plant, and not necessarily a *root* (of a tree). I claim, therefore, to ask Mr. Wild, does not the presence of *Stigmaria* in strata just below a coal bed militate against the land surface *in situ* theory? I have for some time back argued that it is only in *abnormal conditions*—in comparatively very few places indeed—that any *direct connection* between the fossils in underbeds and the overlying coal seam can be seen or demonstrated to exist or have ever existed. In this connection I should just like to observe that in nine cases out of ten, wherever you come upon unmistakeable fossil wood tissue in a coal bed, or plainly visible plant remains, they are in the shape of *impurities* in coal—not coal themselves. While such a fact may be used against a vegetable origin for coal, it still seems to *prove* nothing.

As to fossil mollusca referred to by Mr. Wild (page 554), if he will take the trouble to look at the uppermost

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stratum of Section "B," and divisional layer No. "57," page 533, he will find an answer to his question.

Then in regard to "wash-outs," Mr. Wild says: "With respect to that so-called wash-out, I cannot consider it at all a wash-out. It is more probably a wide rent." If "*that* so-called wash-out" means my fig. "sketch G," page 528, I quite agree with him. I called it "an irregular-shaped vein or tongue of extraneous matter filling opening in the seam"; and I think a careful re-reading of the text will show that I did not class this vein with the "wash-outs" and "wants."

It seems evident to my mind, on the face of it, that the filled-up gash in Fig. G represents an ancient rupture of the seam, which has been filled up at two distinct periods and by two differently constituted deposits of mud (see "*a*" and "*c*.") That one of these two deposits was there before the other (it seems likely that "*c*" was there first) is evident from the presence of the dividing line or parting, "*b*," and the plicated layers seen in each deposit on either side of "*b*." This rent or fissure must have been re-opened in order to let in the second of these deposits; after which the whole thing was tightly squeezed together.

The angular blocks of coal and of sandstone mentioned in my paper and criticised by Mr. Wild, have not, to my knowledge, been met with except in *bona fide* wash-outs in the Moira Main coal. I do not understand what Mr. Wild's remark about "water-worn pebbles" (see page 554) has to do with this filled-in gap. Either I did not express myself clearly in regard to these wash-outs, &c., or Mr. Wild has misunderstood my "Sketch G."

On page 555 he states that "Ferns become almost pure coal," but it would have been interesting to learn from him how he knows that.

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I think the remarks about "cleat" which were made by Mr. Dickinson and Mr. Burnett were a trifle outside of the subject of the paper. I merely incidentally mentioned the presence of it in the coalbeds of the Leicestershire field viewed as a whole.

The President's statement that very many fossil trees have been found in an erect position with their *roots extending under the coal*, seems to me to require a little proof. So far as my researches have gone, such things are exceedingly rare. How many instances did Professor Williamson get together in that splendid monograph on Stigmaria? How many cases do we find in Text-books, &c., compared with recorded observations in the field?

There is one of my own statements that ought to be criticised by myself, as no one seems to have noticed the mistake. On page 535, in my description of the "Dice" variety of the coal, it is stated that it "contains most volatile matter of any variety of the seam"; but the chemical analyses on page 530 show that that coal contains *least* volatile matter of the three examined. No doubt the discussion being taken before the paper was issued to members accounts for this, as well as for some of the remarks made and alluded to above.

I think it is rather to be regretted that so much of the discussion bore upon the *growth-in-place* v. the *drift* origin of coalbeds. I tried to avoid bringing up this controversy in my paper by sticking to *facts* as much as possible, with the idea of drawing out new ones from members of the Society; but it seems I have, so far, failed in a great measure to elicit anything new from the Manchester district, though it cannot be for lack of competent observers.

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Professor Boyd Dawkins: One remark I should like to make, and it relates to the bringing up again of the idea which has been exploded over and over again in this country of the *Stigmaria* being an aquatic plant. That is an opinion which, as far as I know, no English botanists of the present time hold; and I am perfectly surprised to find any man who knows what *Stigmariæ* are, and where they are found, can imagine for one moment that they could be aquatic. They are simply the roots of Lepidodendroid plants. The very fact of finding them mostly embedded in old surface-soil, as they are, is dead against their being what Mr. Gresley supposes them to have been—aquatic plants floating in the water.

Mr. George Wild: My answer to the first paragraph in Mr. Gresley's "Reply to Discussion," which affects myself, is that in my opinion there is *no* "reliable authority on fossil botany" who will dispute that the great plants of the coal period, *Sigillaria* and *Lepidodendron*, were trees, nor that the fossils known as *Stigmaria* were the roots of one or both of those trees. To the question in the latter part of the same paragraph, my answer is *not at all*, any more than does the presence of the roots and root stocks of trees in the clays, &c., under the bogs in Ireland and elsewhere, militate against a land surface upon which such trees grew. Besides *Stigmaria* are not confined to under-clays, but are met with in the coal itself. See Mr. Gresley's Section numbers 1, 52, 57, 59, 74, 76, 96 and 102 layers. With regard to the latter part of the same paragraph, I will only ask that Mr. Gresley examine the connection between the roots of the trees which have grown on the spot, where the peat beds or bogs have been formed from their decomposition, and that of plants of humbler growth, to find that it can only be in *abnormal conditions* that such a connection as he speaks of need be expected. The observations with

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respect to "plainly visible plant remains," are erroneous, as specimens on the table prove, therefore his deductions from so-called *facts* are erroneous. See *Sigillaria, Calamites,* &c., on the table. I am obliged to Mr. Gresley for pointing out his remark in the Section, *layer 57,* "*Anthracosia* very rarely seen." I have carefully re-read the text relating to the third kind of fault found in the seam, viz., "*Faults of erosion,*" and must say that Mr. Gresley's description would lead most people to understand that he meant Sketch G as representative of *faults of erosion, wants,* or *wash-outs.* However, the explanation corrects that misunderstanding, and gives in detail the mode of occurrence as it appears to himself. My remarks with regard to the angular blocks of coal and sandstone were made for the purpose of showing that it was more likely that they had fallen into the rent or gap from its sides, and did not indicate erosion, or abrasion, from the action of water forming a wash-out. His last paragraph, referring to my remark that "Ferns become almost pure coal," I may answer by saying that, if Mr. Gresley had been present at this meeting, I could have shown him by the specimens on the table that such is the case, and not only ferns, but, also almost all other plant impressions when not mineralised by foreign substances, or decomposed by maceration, the more indestructible portions are converted into coal.

Mr. Wild added: When the Society paid a visit to the Preston Docks some time ago, I picked up a few fragments of wood which had been for a long period buried in the mud. One was 1½in. to 1¾in. diameter, and had the bark on; another had been mineralised to some extent with some ochre (oxide of iron probably); and another was a piece of timber, very black and hard. These fragments I have brought for inspection to-day. That with the bark on I thought would make a very nice section, but after lying in

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my cabinet for a few days it began to shrink, and the bark fell to pieces, being a black carbonised mass. The wood which remained shrank to about one-half its original diameter, and was mineralised, just as we see fragments of fossil wood mineralised. The other specimen is very hard—so hard that it is hardly possible to cut it with a knife. The two latter specimens will burn indifferently. We have examples of mineralization of this kind from the coal. One is here from the Wood Park Colliery: The specimen is the woody centre of a *Stigmaria.* It exhibits a very fine structure, and on being heated, oily matter exudes. That is another degree of mineralisation. By examining the outer bark of the *Stigmaria* or the *Lepidodendron* or ferns in some cases, you find—if it happens not to have been destroyed—that it is pure coal throughout its entire thickness, the woody portion having become mineralised—just as these specimens from Preston have been—whilst in other cases the inner portion of the woody mass has rotted and been carried away, leaving a cavity which has become filled with the surrounding mud.

Mr. De Rance: I should like to mention in connection with this matter that on Wild Boar Fell, on the borders of Westmorland and Cumberland, between Kirkby Stephen and Sedbergh, there are in the Lower Carboniferous or so-called Yoredale Rocks certain bands of Gannister, not associated with coal, in which you constantly find *Stigmaria;* and it is a common thing there to find a *Stigmaria* coated with rather more than a tenth of an inch of pure coal; and the material inside of what was once, a plant has evidently decomposed, and its place been taken by the Gannister mud, similar to that which surrounds the barky portion. So that when you examine one of these specimens you have a cast of *Stigmaria,* made up of Gannister of great weight, surrounded by a coating of pure coal, with a cubical fracture, which in every

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way corresponds to a pure coal. It seems to me a matter of regret that an author, evidently of considerable ability, should bring before us views that are altogether retrograde, as Professor Dawkins has well pointed out. It is pretty much the same controversy as that relating to peat mosses—as whether the trees now found under the peat grew on the sites on which we find them. No doubt many trees have been swept down by floods, but it is equally certain that a large number—as those at Altcar and other places in South-West Lancashire—have got their roots well down into the grey clays; in fact, in some districts I have seen the roots penetrating the boulder clay itself. At the period of the obstruction of drainage, the water rose to a certain height up the trunks, these trunks became decomposed between wind and water, and then a great wind blew down the trees at the line where the waters edge was; and there you get the trunks with their heads all lying in a particular direction. It has been always impossible for me to understand how anyone can maintain that these, were deposited in water, after being drifted from great distances. It appears to me, the author, whilst he talks about "facts," and the recording of nothing but facts, has certainly—so far as I can gather, and I think Mr. Wild has conclusively established it—brought before you certain circumstances which are more in the nature of theories than of facts, and our thanks are due to Mr. Wild for having cleared up these points.

Mr. Stirrup: With reference to some remarks made by Mr. Tonge at the previous discussion of Mr. Gresley's paper to the effect "that very many fossil trees have been found in an erect position, with their roots extending under the coal," Mr. Gresley says this statement requires a little proof, as, so far as his researches have gone, such things are exceedingly rare.

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In Mr. Tonge's absence, I may say that I have received a letter from him, in which he says, in reference to Mr. Gresley's note upon my remarks as to *Sigillaria* and *Stigmaria:* "I may repeat that I have frequently seen the *Stigmaria* standing in the clay floor, and the *Sigillaria* above it, either exactly over or nearly so; and if any member would like to see such a case at the present moment, I can take him to a place at Hulton Colliery which is a very good illustration. The seam is the Hulton Three-quarters Mine, the next workable seam above the Arley Mine."

Mr. Stirrup continued: Mr. Gresley seems to be in doubt as to whether there are many examples of fossil erect trees found *in situ*, and he evidently desires that there should be more proofs brought forward. Unfortunately, many of these instances that are met with in the working of our coal beds are not brought before any scientific society, and are not published or made known, and therefore there is not that information available which scientific men would like. I should be very glad if gentlemen connected with collieries, when they find instances of roots of *Stigmaria, in situ*, with *Sigillarian* stems extending through the overlying strata, would bring them under the notice of the Society, because, when published, it would be of great benefit to the scientific world, as undoubtedly the view is entertained on the Continent, and especially among German botanists, that they are all drifted specimens which occur in the Coal Measures. As affording another instance of what Mr. Gresley asks for, I happened only this morning to take up the Transactions of the Leeds Geological Association, Part III., 1891-92, and there I find a copy of a photograph of a fine Carboniferous tree found in the Gannister beds at Meanwood, Leeds. In the letterpress referring to the photograph, speaking of the beds of the Gannister series of the Meanwood valley, it says: "From time to time tree stumps with large roots

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have been found at various horizons in this series, and during the last twelve months eleven such have been unearthed. Eight of these were in the grey Gannister series, the remaining three being in the fire-clay, the largest being represented in the photograph. It stands about the middle of the Gannister beds, 24 feet from the surface of the ground; the stump, 4 feet in height and 11 feet in circumference, is marked by broad longitudinal flutings, and the roots have similar but finer markings, and the usual pittings characteristic of *Stigmaria*. Four roots are seen, two in part and one altogether, whilst the fourth was unfortunately blown away by the dynamite shot. The markings, however, which it has left on the rock beneath, show that the first bifurcation took place on its under surface, 1 foot 9 inches from the junction with the trunk on the inner side, but 9 inches further away at the outer edge. The other large root, which is well preserved, bifurcates for the first time about 2 feet from the trunk, and the two branching roots stretch out along the plane of the bedding. The second bifurcation of one of these roots takes place 4 feet 6 inches from the trunk." With regard to the opinion expressed by Mr. Gresley of the *Stigmaria* being an aquatic plant, I somewhat differ from Professor Dawkins and other speakers as to its being an altogether exploded idea. I believe it to be certainly a very living theory at the present time. It is supported strongly by M. Grand' Eury, a geologist of large experience in the Loire Coalfield, and M. Renault, a palæo-botanist of great authority in France, holds much the same views. M. Grand' Eury speaks decidedly of the *Stigmaria* as an aquatic plant growing in deep water or on inundated soil, and the reason we find *Stigmaria* in their original position is because of that very fact, that they grew under water, rooted in the mud and were thus able to withstand dispersion by flood waters. An illustration of a

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similar kind of growth at the present day would probably be the mangrove tree, which grows in tropical climates and the delta swamps of the Mississippi. Another circumstance connected with their organic structure supports the theory of their having been aquatic, namely, that the vessels of these fossil plants are much larger and apparently of a more succulent nature than those of land plants at the present day. I do not say that this fact is conclusive of their aquatic nature, but it shows, at all events, that this opinion is not yet exploded. A voluminous memoir has recently been published by M. Grand' Eury, in which he discusses the nature of Coal Measure plants, their mode of growth and fossilization.

Professor DAWKINS: I am perfectly aware that M. Grand' Eury holds these views, but I do not think they are any the less not exploded for that reason. The very first account we had of the *Stigmaria*, I think, was an account of it as an aquatic plant—somewhere about the first quarter of this century—and certainly the labours of systematic botanists in Germany and in this country have to my mind exploded that idea. I can only wonder at the nature of the evidence brought forward, indeed I have not seen any evidence—I do not know to what kind of "vessels" Mr. Stirrup refers.

Mr. STIRRUP: I mean the botanical characters—the microscopic vessels of the plant itself.

Professor DAWKINS: I do not think if anyone will take the trouble to examine the microscopic structure of *Stigmaria*, he will be struck with the enormous size of the vessels. I do not think they are much larger than those which can be found in abundance in *Lepidodendron* and others.

Mr. STIRRUP: The vascular tissue has no doubt suffered some contraction from desiccation during fossilisation. You

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must allow for that when comparing them with land plants. But the subject is one which will furnish material for discussion, I believe for years to come. It is a controversy by no means settled and disposed of.

ON THE RELATION OF GEOLOGY TO THE POPULATION AND AGRICULTURE OF ENGLAND AND WALES.

By C. E. De Rance, Assoc.Inst.C.E., F.G.S., F.R.G.S., F.R.Met.Soc., of the Geological Survey of England and Wales.

Population.

After preparing a county population density map to form one of the plates in my book, on "the Water Supply of England and Wales," the figures of the Census taken in 1881 were issued by the Registrar-General, and I found that considerable changes had taken place in certain counties since 1871, and it became necessary to prepare another map to express the altered conditions, the number of acres to each person in some being greater, in others less.

The publication of the figures of the 1891 Census, enables a triple comparison to be made, with the result that the counties of increase, and the counties of decrease of 1881, remain so respectively in 1891, the process of depopulation steadily continuing in certain areas, throughout the whole interval of 30 years, while the converse process of centralisation still continues in others. In Appendix I. to this communication I have given the area in acres of each county of England and Wales, and the number of acres, or parts of one acre, per individual living in each county in 1871, 1881, and 1891. The percentage of the Geological Formations in general groups, viz.:—1, The Tertiary; 2, The Cretaceous; 3, The Weald, Oolites, and Lias; 4, The Trias and Permian; 5, The Coal Measures; 6, The Lower Carboniferous, Culm Measures, and Old Red; 7, The Cambro-Silurian, Igneous,

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and Volcanic Rocks. I have added the percentage in each county which is under—(1) Corn; (2) Permanent pasture; and (3) Moorland, Forests, Towns, and waste lands.*

The counties of England and Wales, as regards population, may be conveniently divided into nine groups, as follows:—

A.	Less than	0·1	of an acre per individual	....	1 county.
B.	,,	1·0	acre ,,	....	9 counties.
C.	,,	2·0	acres ,,	....	13 ,,
D.	,,	3·0	,, ,,	....	11 ,,
E.	,,	4·0	,, ,,	....	10 ,,
F.	,,	5·0	,, ,,	....	4 ,,
G.	,,	8·0	,, ,,	....	3 ,,
H.	,,	9·0	,, ,,	....	2 ,,
I.	,,	13·0	,, ,,	....	1 county.

Groups H, I, with from 8·5 to 12·0 acres to the individual, are all in central Wales, and are wholly occupied by Cambro-Silurian rocks. This is the area that shows the most marked tendency to depopulation, and is the area from which the Corporations of Liverpool and Birmingham are taking, or about to take, the supplies of water necessary for their congested populations.

Group G is adjacent, and is formed by Cardigan and Merioneth, which are also entirely made of Cambro-Silurian rocks, as is nearly the whole of Westmoreland, the sole representative of this group in England. The smallest population, and that most rapidly diminishing, occurs in the Cambro-Silurian area of South Britain, which is the wettest portion of the country, its hard mountain peaks wringing the moisture out of the prevalent western winds, which moisture is being made available for human requirements in Westmoreland by the Manchester Corporation Water Works, in all these cases, the water so used is water that would otherwise be lost and escape in devastating floods.

It is interesting to note that this group of Welsh counties form, with Carnarvon and Carmarthen in Wales, and West-

* These per centages are taken from my Colleague, Mr. W. Topley's paper, on the Comparative Agriculture of England and Wales. Royal Ag. Soc. 1871. Founded on Board of Trade Returns for 1867.

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moreland in England, the area of largest percentage of moorland and waste lands for agricultural purposes, rising in Merioneth to no less than 70½ per cent., and in Westmoreland to 54 per cent. Carnarvon, with more than half its area waste land, owes its higher density of population to the slate industry, and to the advantages offered by the Menai Straits for the interchange of trade shipments in the ancient city of Carnarvon and at Bangor; while Carmarthen owes its higher density of population to the fact that, though three-quarters of the county is occupied by Silurian, the remainder has 12·6 per cent. covered by corn crops, most of which overlie a productive coalfield.

In this respect Carmarthen may be usefully compared with the county of Cumberland. Both counties have more than half their area moor and waste land; both contain a coalfield, and both support a population, having nothing in common with the adjacent Silurian area. The density of Carmarthen being 4½ acres to each person, that of Cumberland 3·8, in both cases if the population, instead of being averaged over the whole county, had been taken out separately on each geological formation, the Central Wales, or Cambro-Silurian type of population, would have appeared in strong contra-distinction to the coal measure areas.

In Group F, the conditions described in Carmarthen also exist in Pembroke as regards the presence of part of the coalfield, the indented coast line and safe harbours, and the agricultural character of a portion of the county, for, though moorland and unproductive areas occupy 31·8 per cent., 16·1 per cent. is covered with corn crops and 3 per cent. with green crops.

In Herefordshire, though there is no mineral wealth, corn crops occupy 20·8 per cent., green crops nearly 6·8, and permanent pastures 42·1, and of the so called waste of 22 per cent. a large portion will be occupied by orchards yielding

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perry and cider; but nevertheless it is without manufactures, without which few districts appear to be able to keep the population even at par, and the population is diminishing. This is still more marked in the remaining county of this group—Rutland—where there is half an acre per individual more than in 1871, though corn crops occupy 29 per cent., green crops 8 per cent., and permanent pasture 38 per cent.; whilst waste land, including woods and towns, only occupy 18 per cent. Here, with soil resulting from the decomposition of the fertile oolites, small rainfall, moderate climate, ready access to markets by rail, emigration is taking place, through causes which are not far to seek.

Group E consists of the following, with their characteristics:—

Cumberland	Coal and Metalliferous Mining,	Corn 4·7%
North-Riding, York	Metalliferous Mining, Manufacturing	,, 17%
Lincoln	Machinery	,, 35·4%
Huntingdon		,, 45·7%
Wilts		,, 26·0%
Dorset		,, 18·2%
Salop	Coal Mining	,, 22·2%
Denbigh	Coal Mining	,, 18·1%
Carnarvon	Slate Quarrying	,, 6·7%

Two areas occupying more than half of Cumberland are waste lands, only supporting mountain sheep, one occurring to the west on the Lower Silurian Mountains, and the other to the east on the Lower Carboniferous Fells, rising in mural escarpments from the Vale of Eden to a height of more than 2000 feet, but the villages are situated at the foot of the scarp, on the Permian rocks, and each township extends upwards, and over the watershed, so that each farm has a lowland homestead on the Permians, and an upland feed for their sheep on the Carboniferous moorlands. These, in the district further to the east, are inhabited by an upland mining population, whose children, as a rule,

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have never seen a plough, and are as ignorant of the aspect of wheat-growing as they are of that of rice. Metalliferous mining, through the fall in the price of lead, is heavily depreciated, and numerous cottages are untenanted and falling into decay; this is strongly the case in Swaledale, in the adjacent county. In this district also are many deserted substantial farmhouses, formerly occupied by "statesmen," as they were called—yeoman farmers owning the land their flocks wandered over.

Group D comprises the following counties, which may be sub-divided into three:—

		Corn. Per cent.	Waste. Per cent.
1.	Cornwall	17·0	43·9
	Devon	18·2	39·1
	Somerset	15·0	24·1
2.	Northumberland	12·2	36·0
3.	Oxford	35·6	11·7
	Northampton	30·3	14·8
	Bucks	30·8	15·2
	Cambridge	51·6	10·5
	Norfolk	35·9	22·3
	Suffolk	41·8	20·8

Group C consists of the following counties, which may be sub-divided as follows:—

		Corn. Per cent.	Waste. Per cent.
1.	Monmouth	12·0	40·6
2.	Derby	12·9	27·1
	Notts	32·0	17·2
	Leicester	23·3	10·1
	Worcester	27·6	18·18
	Gloucester	23·1	2·124
	E. Riding York	37·0	13·3
3.	Bedford	40·8	15·1
	Berks	33·8	18·4
	Sussex	23·2	32·1
4.	Hants	24·9	36·0
	Herts	40·0	15·5
	Essex	40·3	24·6

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The general results of Groups E, D, and C show that in the absence of any manufacturing processes, the Oolite, Cretaceous, and Tertiary areas can maintain one individual on from one to two acres, but when the district is elevated, as on the Dorsetshire hills, Wiltshire plains, or Lincolnshire wolds, nearly four acres are required for each person.

Group B, in which there is less than one acre to each inhabitant, occurs under two conditions, contiguity to the Metropolis, *i.e.*, Surrey and Kent, portions of which now form the new County of London, or they contain an important *coalfield;* to this latter category belong Durham, Lancaster, Chester, Stafford, Warwick, and Glamorgan, the last being the only county in Wales with a dense population, it is worthy of note that density to a more limited degree follows the South Wales Coalfield, eastwards into Monmouth, and westwards into Carmarthen, and across the Bay into Pembroke.

Only three counties in Wales had *increased* in population in 1891, and all contained coalfields, viz. :—Glamorgan, Carmarthen, and Denbighshire. It may be well here to observe that only five counties in England are found to have a *reduced* population, viz. :—Cornwall, Herefordshire, Huntington, Rutland, Shropshire.

In Cornwall out of 14 registration districts 11 show a loss in three districts being of more than 2000 inhabitants; the positions appear to point to failure of metalliferous mining. In Hereford, a loss is recorded in the whole of the seven districts, and is largest in the city itself; this is obviously due to agricultural depression, which looking to the natural fertility of the soil, from the decomposition of the Old Red Sandstone, the existence of a special breed of cattle accustomed to the soil, of which 42 per cent. is permanent pasture, points to the land having a fictitious

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value, which cannot earn the necessary incomes to cover the expenses of working it.

In Shropshire, though the population is helped by a small coalfield, the same position of affairs obtains, out of 15 registration districts only three show a slight increase, whilst all the others have a decrease, in Madeley of no less than 4,160, and in Wellington of 2,407. This emigration of inhabitants in a purely agricultural district points infallibly to the impossibility of obtaining a living from the land with its present burdens from agriculture alone.

In Huntingdon, with exceptional conditions as to climate, rainfall, oolitic soil, and access, the three registration districts show a decrease, as do the two districts of Rutland, though to a less marked degree.

Group A consists of the solitary county of Middlesex, with only 0·05 of an acre to each individual over the whole area, and far less than this is the actual Metropolis, the influence of which extends into the adjacent home counties.

The existence of London has most certainly geological conditions to thank for its existence. The gravel soil of the Thames alluvium, near the end of the limit of influence of ordinary tides, and beyond exposure to the storms which the small boats of the past must have felt far more than existing craft, a suitable place for the interchange of merchandise, with drinking water readily accessible, and wood for fuel on hand from the forests of the Weald, physical conditions originated the settlement of London.*

Agriculture.

Examining the percentage of corn grown in England and Wales, the country may be naturally divided into seven groups:—

* In the following observations I have freely availed myself of the valuable papers by my colleague, Mr. Topley, F.R.S., viz.: "Comparative Agriculture of England and Wales." J. R. Ag. Soc., Vol. VII. "On the Agriculture of the Weald." J. R. Agric. Soc., Vol. VIII.

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A.—With less than 5·10 per cent. under corn, Cumberland, Westmoreland, and Merioneth, and chiefly Silurian.

B.—Less than 10·10 per cent., Lancashire, Carnarvon, Radnor, Brecknock, and Glamorgan. The first and last named contain coalfields, and also have a large area of upland Lower Carboniferous rocks above the limit of the growth of corn, whilst the remainder are Silurians.

C.—Large areas of upland Silurians keep down the percentage of corn lands in Montgomery, Cardigan, and Carmarthen; of Old Red amd Devonian in Monmouth and Somerset; of Lower Carboniferous in Northumberland, the West Riding of Yorkshire, Derbyshire, and Chester, in which latter county the Keuper Marls also underlie, the greater part of the 46 per cent. of the county under permanent pasture.

D.—The Glacial Drift overlying the Silurians of Anglesea, Denbigh, and Pembroke is the chief cause of these counties being above the Welsh average, while the counties of Cornwall, Devon, and Hereford are due to the decomposition of the Old Red and Devonian. The Glacial Drift is mainly the soil in which the corn crops of Stafford are growing, as is also the case in Durham, but the percentage is somewhat fallacious, as but little corn is grown on the Lower Carboniferous upland region. This is still more true in the case of the North Riding of York, as were the basin of the Swale and Ure excluded, and the average taken from the area of the basins of the Esk and Derwent, the average from the Trias and Oölites land would be as high as they are in the adjacent East Riding, which is no less than 37 per cent.

Group E.—A quarter of the ground, more or less, is under corn in Flint, Salop, Warwick, Leicester, Worcester, and Gloucester, consisting of New Red and Permian beds, to some extent overlaid with Glacial deposits in the two first; Coal Measures also occur in these counties, but the corn is

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chiefly on the newer strata. This is especially the case in Flintshire, where the chief corn lands are found fringing the coalfield, and in the Vale of Clwyd, which enjoys a climate quite distinct from the rest of Wales, the rainfall at Rhyl for the last five years averaging only 23 inches, or less than any other locality in the west of Britain, from John o' Groats to the Land's End, and has a remarkable immunity from fogs. To its dry and equable climate is due the fact that Flint is the only county in Wales growing anything like its percentage of wheat, namely 9·5 per cent., which is above that of Kent and Hants, and far above that of Lancashire and Cheshire. In Group E also are the Oolitic counties of Northampton and Bucks, and the mainly Cretaceous counties of Wilts, Hants, Surrey, Sussex, and Kent.

The two remaining Groups, F and G, are wholly situated in the east of England, within the area of least rainfall, the moisture of the prevalent wet winds having been largely abstracted by the elevated escarpments of the various Lower Secondary Rocks, which eastward tilt traverses England in a S.S.W. direction from Lyme Regis, to the N.N.E., at Whitby.

The following is the characteristic feature of each group:—

		*	Wheat. Per cent.	Barley. Per cent.	Corn Crops. Per cent.
Group F.	East Riding, York	T. L. & C.	17·0	6·2	37·0
	Notts	T. & L.	14·1	8·9	32·1
	Lincoln	L. O. & C.	18·1	8·1	35·4
	Bedford	O. & C.	18·0	9·7	40·8
	Oxford	L. O. & C.	13·3	10·9	35·6
	Berks	O. C. & T.	14·3	8·5	33·8
	Herts	C. & T.	15·9	11·7	40·0
	Essex	C. & T.	18·3	9·9	40·3
	Norfolk	C. & T.	15·0	14·3	35·9
Group G.	Huntingdon	O.	21·2	8·8	45·7
	Cambridge	O. & C.	24·9	10 5	50·6
	Suffolk	C. & T.	16·4	14·5	41·8

* The letters in the above table stand as follows.—[T]rias; [L]ias; [O]olites; [C]retaceous; and [T]ertiaries.

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From this table it would appear that the largest crops of corn, and especially wheat, are found in the areas occupied by the oolites—and the chalk where overlaid by Boulder Clay, where the average rainfall is low, and the gradients applicable to steam cultivation; where these two conditions do not obtain, the averages are much lower on these formations. From this it can be seen, as has been well stated by my colleague, Mr. Topley, F.R.S., "Agriculture depends on climate, climate mainly on contour, contour mainly on geological structure."

If it were possible to ascertain the extent of the crops growing over each formation, in each county, the results would be often startlingly different, thus, as pointed out by Mr. Topley; Hereford has 55·4 per cent. of its corn land under wheat, and it is not even reckoned a corn county. The average of the so-called corn counties is 60·4 per cent. of the arable land, but Leicester has 67·3, its low place in the corn being due to the wide extent of pasture land over the Lias. The New and Old Red Sandstone cause the high percentage of corn, in the whole arable land, in the West Midlands.

Barley ripens quickly, and, therefore, requires a shorter high summer temperature than wheat, which accounts for its high percentage in Wales, and the coast counties where it is controlled by *climate*, whilst on the east coast it is controlled by *soil*, the English counties standing as follows: Norfolk, Rutland, Suffolk, Cornwall, and Dorset.

The highest percentage of fallow is in Huntingdon, nearly the whole county is Oxford Clay, partly overlaid by Boulder Clay, and as might be expected, the population is diminishing.

Hops will grow on many soils, and on upland slopes, when protected from the wind. 63 per cent. of English hops are grown in Kent, the remainder in Sussex, Hereford,

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Hants, Worcester, Surrey, a loamy soil, or a clay sub-soil seems to be required. Hop farms, as a rule show least enterprise as regards other crops, oats been grown where wheat could easily be raised.

Waste Land.—Including Moorland, Forest, Heath, and Area occupied by Towns.

Examining the percentages given by the Board of Trade, England and Wales may be divided into seven groups:—

A.—With less than 10·10 per cent.: Cambridge, Huntingdon, and Leicester.

B.—With less than 20·10 per cent.: East Riding of York, Lincoln, Notts, Rutland, Northampton, Bedford, Herts, Bucks, Oxford, Berks, Wilts, Warwick, Worcester, Salop.

C.—With less than 30·10 per cent.: Anglesey, Chester, Stafford, Derby, Norfolk, Essex, Kent, Dorset, Somerset, Gloucester, and Hereford.

D.—With less than 40 per cent.: Northumberland, Durham, North Riding of York, West Riding of York, Lancashire, Denbigh, Flint, Monmouth, Devon, Hunts, Middlesex, Surrey, Hants, Sussex.

E.—With less than 50·10 per cent.: Cardigan, Radnor, and Cornwall. Due to upland granitic and volcanic rocks.

F.—With less than 60·10 per cent.: Carnarvon, Montgomery, Carmarthen, Brecknock, and Glamorgan, wholly on Cambro-Silurian Rocks.

G.—With less than 70·10 per cent., consists of only one county—Merioneth, of which 70·4 per cent. consists of waste lands. That this county is not the most thinly populated in Wales, is probably due to an artificial population, who exist on supplying summer visitors; but, notwithstanding this adventitious aid, the population has materially diminished in six out of the eight registration sub-districts. The county is wholly situated on Cambro-Silurian Rocks.

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The Palæozoic rocks of older date than the Devono-Carboniferous, of Cumberland, Westmoreland, Carnarvon, Merioneth, Cardigan, Montgomery, Radnor, Carmarthen, have from 42 to 70 per cent. of their area upland pasture, unproductive moors, and areas which are enumerated by the Board of Trade as "waste lands," and form Group E, F, G of the Waste Land category, in which is the county of Brecknock, and the Coal Measure county of Glamorgan, which alone of all Coal Measure counties of England and Wales has more than half its area under waste, but yet maintains the greatest density of population of any county in the Principality, apparently showing that it is almost immaterial in a coal-producing county whether agriculture is carried on or not, as with ample food-purchase power, provisions can be readily supplied by outside markets.

Geological considerations, with one exception, govern the comparatively high amount of waste land in the 14 counties forming Group D. In Devon it is due to the high peat-covered Granite Tors, and upland moorlands of Dartmoor; and in Monmouth to the prolongation of the Old Red bare Brecon Vans, which are still more sterile, though doubtless capable, with judicious planting, of supporting forests of considerable value. Lower Carboniferous rocks, consisting of alternations of sandstone and shale, are responsible for the large amount of hill pasture and absolute waste in Northumberland, Durham, North and West Riding of York, and Lancashire. In Denbigh a considerable area of Silurian strata occurs, and the 38·3 per cent. of waste land is probably chiefly on it, as the Carboniferous Basement beds and the Coal Measures are fairly well cultivated. In Flintshire the waste land is partly also Silurian, forming the Moel Fammau watershed between the Dee and the Vale of Clwyd, with the Carboniferous Limestone upland pastures on either side. Bagshot sands in Surrey occur largely, and explain the

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high percentage there, which in Sussex is due to bare chalk downs, forest lands in the Weald, which ought not to be reckoned as waste, nor should the chalk upland, which sustain the celebrated Southdown sheep. In Middlesex the waste land *(sic)*, for the purposes of agriculture, is occupied by buildings and streets, and is probably the most valuable land per square yard in the civilized universe, due to its safe and easy access as a port, on the chief tidal river nearest to the Continent.

GEOLOGY.

In Appendix I., the area of groups of strata, given in their approximate percentages of the whole area of the county.

In the Cambro-Silurian counties of Wales and the N.W. of England, much land is returned as "Waste" which is really hill-pasture, blending into absolute moorland. Permanent pastures occupy the lower slopes, and narrow strips of corn lands occasionally occur in the bottom of valleys or on terraces of drift, above the alluvial plain, which is generally under permanent pasture, and often subject to inundation from floods. The comparatively low elevation of Anglesea, its western aspect, and drift-covered surface, produces the highest percentage of rotation grasses and oats of any county in England or Wales.

Barley in Cardigan, manured with sea weed and sea sand also, has been cropped off the same field for 100 years in succession. In Pembroke and Carnarvon, the percentage of barley is double that of wheat, and is higher in Anglesea, Merioneth and Carmarthen. This is not the case in any English county. In Westmoreland the proportions are equal.*

The old Palæozoics rise to about 1000 feet in the Malvern Hills, on the Herefordshire and Worcestershire borders, and

* W. Topley, F.R.S., Comparative Agriculture of England and Wales. J. R. Agricultural Society, Vol. VII., S.S., Part I.

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form an area of waste lands, as do the smaller tracts of Charnwood Forest Rocks in Leicestershire, which only rise 850 feet above the sea.

The granitic and slaty rocks of Cornwall and Devon, as regards the high land they form, differ from the other mountainous districts of Great Britain in the upland area, occurring in insular patches, as has been already pointed out by Mr. Topley in the paper so often before referred to, in which he points out, that though the granitic (or "growan") soils are barren at high elevations, they furnish the most prolific soil in Cornwall as low levels.

The Carboniferous Limestones afford good grazing ground up to about a 1000 feet above the sea in the Mendips in Somersetshire and in the Derbyshire hills, further north—it is split up with beds of shale and sandstones, and the various beds occur in long terraces, which dipping at a slight angle to the slope of the Yorkshire rivers, Yore and Swale, disappear from sight one by one. Traversing these deep Dales, we find trees cease to grow at above 1500 feet above the sea, oats at about 900 feet; cows are found grazing on rich grass up to 1000 feet on limestone bands, their milk yielding the noted Wensleydale cheese, but above that level, sheep alone get a scanty subsistence from the rough grass mixed with heather, the sheep are of the Cheviot breed, and the Herdwicks, which wander to the top of Scaw Fell, in the Lake District are not seen. The limestones are still more unimportant in Northumberland and in Durham, where the hills are capped by Millstone Grit, and the limit of cultivation of them generally occurs at 800 feet above the sea.

The Millstone Grit in the South has never any coal seams in it, and is consequently often called "The Farewell Rock." Further to the north it increases in importance, and contains workable coals, but of no great thickness; it forms the wild

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uplands of Cheshire, Lancashire, and Yorkshire. The water absorbed by its porous beds, reappears as springs, so that nearly the whole of the rainfall is recoverable. This has led to the establishment of the cotton and wool industries in many wild valleys which are adjacent to coalfields.

The presence of a coalfield in a county invariably directly influences its population. Every county in the first two groups of densest population include a coalfield, except the Metropolitan counties of Middlesex, Surrey, and Kent. The influence is not only felt in the cotton and wool industries, but governs others, which spring up beside a cheap coal supply, as the "cycle" industry at Beeston and Coventry, plate glass at St. Helens, chemicals at Widnes, watches and watch springs at Prescot and Coventry.

In the Permian and Trias the hard conglomerates of the former rise in Worcestershire, at Enville and Frankly Beeches, and form upland tracts of rough pasture, as do the Pebble Beds of the Bunter, and the Lower Keuper Conglomerate, in Shropshire, Staffordshire, and Cheshire. The Keuper Marls are largely covered in central England with drift, and in parts of Worcestershire, Staffordshire, Lancashire, and Yorkshire they support a population engaged in pumping and boiling brine for the purpose of making white salt.

Oolites in the south do not attain any considerable elevation, most of it is under the steam plough, or consists of downland, resembling in the character of its grasses, those growing on the Chalk Downs. In Yorkshire the calcareous element in the Oolite is nearly absent, and the elevations are often above the 1000 feet contour, and wide expanses of upland moorland occur.

The district known as "The Weald," in the south-east of England, is bounded and surrounded by the North and South Downs, which are abruptly terminated to the east by the

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English Channel and form the steep cliffs near Folkestone and Eastbourne. The oldest formation within this area, rises to the highest elevation on Crowborough Beacon (803ft.), and forms the chief watershed of Kent and Sussex, this central district consists of high lands, part of which is unenclosed, and contains Ashderon Forest, part of which is over 500ft. above the sea. This district in the time of Elizabeth was largely worked for ironstone, the last furnace being put in 1828. The "power" of the hammers was derived from water dammed up in the valleys, and the fuel was the wood that made the now destroyed Forests of the Weald. Intercalated with the sand beds are the Wadhurst and Grimstead clays, they differ from the Weald clay in forming undulating surfaces. The former yielded the ironstone used in making the iron for the cannon of the fleet at the time of the Spanish Armada, and the rails of St. Paul's Cathedral.

Sandy beds occur in the Weald Clay, but the grains are so fine and smooth, that water does not pass through it, but lodges, so that sheep never thrive upon it, some of the sandy beds afford an artesian water supply when bored into; the Weald clay itself is fearfully stiff and cold, though often capable of improvement, the land, unless covered with drift loam, is poor, but when the latter is the case it makes a magnificent hop soil.

The Atherfield Clay, the lowest member of the Lower Green Sand, for agriculture and waterworks purposes may be regarded as part of the Weald Clay; hops flourish well on it where the escarpment is breached by the Medway valley. The outlying Hythe Beds reach the highest altitude of the Green Sand area; it is exceedingly calcareous, and the decomposition of it, "the Kentish Rag," form the fertile soil of Mid-Kent. The middle member, the Sandgate Beds, form a wet tract of sandy clay, requiring heavy drainage,

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the overlying Folkestone Beds generally give light and sandy soils, but near Folkestone are calcareous.

The Gault is a stiff clay above and below with a middle marl, which is known as "the black land," and gives good results when drained and ploughed; the rest is pasture.

The Upper Green Sand contains from 2 to 75 per cent. of soluble silica, and is remarkable for great fertility, especially its wealth of hops and wheat.

The chalk escarpment round the Weald wholly consists of good permanent pasture, except a few woods in which beech is characteristic, yew, juniper, and box are not uncommon. In Sussex large tracts are still unenclosed, and therefore returned as "wasteland," but in reality they are not so, being permanent pasture. Mushrooms grow well on the chalk downs, yielding as much as 45s. an acre to a summer. The Kentish chalk is largely covered with drift and at low elevation it is wholly arable, the Isle of Thanet comparing with the north-west of Norfolk for fertility. The chalk is much covered with drift in Hants, but in Sussex it is bare, and is the home of the South Down sheep. In West Norfolk the chalk hills rise to 650 feet, and are bare or covered with rich calcareous deposit, the boulder clay is absent, and its surface gives the best results of Norfolk farming. Suffolk has little bare chalk, it being overlaid chiefly by barren glacial sands and gravels, and some chalky boulder clay, and to the south by the far stiffer London clay. In Essex, both clays are present in strong force. Mr. Topley in the paper before referred to, of which I have largely availed myself in preparing these notes, points the cause and effects of these variations on Agriculture, in the county of Norfolk, Suffolk and Essex, *i.e.*, going south the fallow division increases, while rotation grasses decrease in the same proportion. The turnip ratio gradually decreases

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from Norfolk to Essex. Beans and wheat increase, traversing the same area, while barley decreases.

Where the old system of farming is carried out on clay and mixed soils—three crops, and then a fallow—manured with what is little better than rotten straw from the litter of the farmyard, even where steam cultivation is employed, the land can seldom be cultivated at a profit, even if held rent free. On this class of farm, steam cultivation has often done actual injury by bringing up sterilized, and therefore "hungry" soil, in which the processes of "nitrification"* do not take place for years.

With labour-saving appliances, scientific knowledge of the nutritive value of food-stuffs and their combined use, so that there may be the smallest amount of waste; of the real nature of manures, and of the duration of their good effects; of the processes of nitrification and the nature of the crop—that is suitable to a soil as regards its own inherent composition—profitable agriculture, in spite of altered conditions of the market, is still possible in England, on farms where the old fallow system is given up and "catch crops" grown, partly "fed off" the land by sheep in spring and summer, whose food is liberally supplemented by cake or corn, thus economically keeping up the manurial value of the land, while the remainder of the green crops is mixed with hay or straw, and made into chaff for cattle in the yard or sheep in the field, where clover is largely grown, which, like other members of the leguminosæ family, has the

* Pasteur suspected that the production of nitric acid in the soil, by which the nitrogen of manures gain access to plants, was the work of micro-organisms, but this was proved, in 1877, by two French chemists—Messrs. Schloesing and Müntz. In 1885, Dr. Percy Frankland showed that micro-organisms can multiply without organic nutriment; in 1886, Dr. Munro showed that the bacteria of nitrification could do the same. In 1886, the subject was taken up by Dr. Percy Frankland and his wife, who discovered the nitrous and nitric acids in the soil, are produced by totally distinct organisms.

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remarkable faculty of absorbing free nitrogen from the air and storing it in the soil, where it is available for future crops. This has been known for 2,000 years, but not the reason why; but, in 1876, Messrs. Hellriegel and Wilfarth showed the excess of nitrogen was obtained from the atmosphere.

Heavy root crops removed from the land rob it of more manurial value than a succession of cereals, which latter can be assisted with the nitrogenous salts—sulphate of ammonia and nitrate of soda. These are popularly supposed to exhaust the soil by stimulating the plants, but they do not, if the correct proportion of phosphatic manure is added to the soil at the time. Farms can only succeed when the cost of working is kept low, and the value of the annual crops increase. To do this, requires knowledge of a high class and considerable capital; therefore the race of small farmers appears doomed, unless they turn their attention to high-value crops on small area, as fruit, mushrooms, asparagus, tomatoes, and other vegetables.

The picturesque water-mill so dearly loved by the artist is now nearly extinct, and with improved milling processes, the coarser and more prolific seed corn gives the best results to the grower, the price, with the existing method of "mixing," like the "blending" of teas, causes the price per bushel to vary but little of various qualities, while the yield per acre may be increased from one to two quarters. The maturing of the crops and the harvest is accelerated by changing the seed every three years, in districts where this is not done, the harvest gradually becomes later and later, and cannot be realized.

An examination of the Cattle returns show an increase of 10·8 per cent. of animals over two years old and a decrease of 2·4 per cent. under that age, pointing to the difficulty of getting rid of the present stock, causing *rearing* to fall off;

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here again it is obvious that well-bred stock, on suitable soils, with cheap foods and good management, would ensure profitable returns, when foreign meat is sold at higher prices than much of the inferior English stock can realize, pointing to the necessity of only rearing high-class stock. This is equally true as regards prices and future of sheep, in which prices have often been less than obtained by foreign mutton. It rests with the English farmer that this should not remain so, but as regards butter it is apparent that farmhouse butter-making, in some districts, is impossible as a profitable industry, the value of the milk being more than that of the butter produced from it, with the labour of its production thrown in. Thus Australia has built up an enormous business in the past three years; but as England possesses a climate eminently suitable for dairy purposes, the finest cattle in the world, and a large area of soils suitable for the growth of food grasses, there can be no doubt this can be remedied by the establishment of butter factories and a wide system of co-operation for the sale of high-class farmhouse butter. The railway companies, in getting the rate of carrying milk increased 66 per cent., are dealing a heavy blow to the milk trade, and meetings just held of Farmers' Associations show that contracts will be terminated and the milk taken to butter and cheese factories, which must inevitably cause hardship to the poor of towns as regard their supply of milk for the tea table, as 224 million gallons of milk are now annually already used in the United Kingdom for cheese-making.

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	Huntingdon	229,515	57,772	3·5	3·8	3·9	21·2	45·7	8·7	25·7	9·9	..	..	..	..	..	100	..	..	..	..
	Wilts	866,677	264,969	3·3	3·2	3·2	11·9	26·0	12·3	35·4	16·3	..	..	..	..	..	35	..	5	60	..
	Dorset	627,265	194,487	3·2	3·2	3·7	7·5	18·2	9·3	35·1	29·3	..	..	..	..	..	40	..	5	25	30
	North Riding, York.	1,361,664	368,237	4·0	3·6	3·5	6·5	17·0	5·8	29·1	40·9	..	..	25	..	20	55	..	..	..	..
	Salop	844,565	236,324	3·3	3·4	3·5	10·9	22·2	8·0	42·2	18·9	20	15	..	15	D 45	D 5	..	..	..	..
	Anglesea	193,511	50,079	3·7	3·7	3·8	1·2	17·0	5·6	34·0	29·5	80	..	15	5	..	..	..	..	..	..
	Denbigh	425,038	117,950	3·6	3·1	3·6	5·3	18·1	3·9	30·3	38·3	70	..	5	15	D 10	..	..	..	..	..
	Cumberland	970,161	266,550	4·5	3·4	3·7	2·8	4·7	2·3	35·2	54·1	16	..	32	D 20	32	..	..	..	..	..
	Carnarvon	369,477	118,225	3·4	3·1	3·2	0·6	6·7	2·3	29·7	52·3	100	..	..	..	..	..	..	..	..	..
F.	Rutland	94,889	20,659	4·0	4·4	4·5	11·0	29·0	8·0	38·3	18·3	..	..	..	..	..	100	..	..	..	..
	Hereford	532,918	115,986	4·1	4·4	4·5	11·3	20·5	6·8	42·1	22·0	10	90	..	..	..	..	..	..	..	..
	Carmarthen	594,405	130,574	5·1	4·8	4·5	2·2	12·6	1·5	29·7	52·3	70	10	5	15	..	..	..	..	..	..
	Pembroke	391,181	89,125	4·3	4·2	4·2	2·3	16·1	3·0	40·8	31·8	60	15	5	20	..	..	..	..	..	..
G.	Westmoreland	500,906	66,098	7·4	7·7	7·5	0·6	4·7	2·3	35·2	54·1	75	..	20	..	5	..	..	..	..	..
	Merioneth	347,717	49,204	8·1	7·0	7·8	0·6	4·9	1·0	20·7	70·4	100	..	..	..	..	..	..	..	..	..
	Cardigan	443,387	62,596	6·0	6·3	7·1	2·1	14·7	2·8	32·4	42·0	100	..	..	..	..	..	..	..	..	..
H.	Montgomery	495,089	58,003	7·1	7·3	8·5	4·8	12·3	2·6	29·1	50·7	100	..	..	..	..	..	..	..	..	..
	Brecknock	460,158	57,031	7·7	7·9	8·6	2·4	7·8	1·8	26·5	59·3	10	85	5	..	..	..	..	..	..	..
	Radnor	276,552	21,791	10·0	11·6	12·0	3·0	9·6	3·1	36·6	46·2	100	..	..	..	..	..	..	..	..	..

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APPENDIX II.

The areas given in the Census Returns of 1871-1881, have been *revised* in that of 1891, England containing 70,328 acres and Wales 9,542 acres less than was believed. Only 13 counties remain unaltered in England, and 4 in Wales. The percentages of density of population in 1871-1881, given in Appendix I., are calculated from the old estimate of the area of each county. The following are the areas assigned to the altered counties in 1871-1881 in the Census of 1891 :—

— Bedford	295,509	+ Notts	526,176
+ Berks	450,132	+ Oxford	470,095
+ Bucks	467,009	+ Salop	841,167
+ Cambridge	524,926	— Somerset	1,049,815
+ Cheshire	705,493	+ Stafford	732,434
— Cornwall	869,878	— Suffolk	949,825
+ Derby	656,243	+ Surrey	483,178
— Devon	1,655,161	— Sussex	934,006
— Essex	1,055,133	— Warwick	566,458
— Gloucester	804,977	+ Wilts	859,303
— Hants	1,032,105	— Carmarthen	606,172
+ Hereford	532,898	— Carnarvon	369,482
+ Herts	391,141	+ Denbigh	392,005
— Kent	1,004,984	— Flint	169,162
+ Lancaster	1,207,926	— Glamorgan	547,070
+ Leicester	511,719	— Merioneth	385,291
— Lincolnshire	1,767,962	+ Montgomery	485,351
+ Monmouth	368,399	— Pembroke	393,682

The changes are generally too slight to affect the percentages, except in the case of Denbigh, Glamorgan, and Pembroke. The sign + or — indicates whether the county is now believed to be larger or smaller than it was in 1881. It is worthy of note that 16 out of the 18 counties that are now returned with less area than before have their coasts exposed to the waste of the sea.

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APPENDIX III.

Agricultural Statistics of the Board of Trade, Estimated in Percentage Crops Grown in Lancashire and Cheshire.

Nature of Crop.	Lancashire.	Cheshire	Maximum Counties. England.		Minimum Counties. England.		Mean. England & Wales.
Wheat	3·4	5·9	Cambridge	25·0	Westmoreland	0·6	9·5
Barley	0·6	0·6	Norfolk and Suffolk	14·5	Cambridge *Cheshire* Cumberland Westmorel'd	0·6	5·4
Oats	4·3	6·5	York, West Riding	10·2	Suffolk Worcester	1·9 1·5	4·7
Rye	0·1	0·2	Norfolk and Suffolk	0 7	Rutland	0·02	0·2
Peas	0·03	0·1	Suffolk	3·6	Cumberland Devon	0 02 0·07	1·0
Beans	0·3	0·6	Bedford Hants.	6·9 6·5			1·5
Total Corn	8·8	13·9	Cambridge	50·6	Westmoreland	4·7	22·3
Potatoes	3·3	3 6	*Cheshire* *Lancashire*	.....	Suffolk, Berks	0·2	1·1
Turnips, Swedes	0·9	1·2	York, East Riding Norfolk	9·9 10·5	Lancashire Westmoreland	0·9 0·02	4·5
Mangold	0·1	0·2	Cambridge	2·8	Rutland, Westmorel'd, Salop, Hereford	0·06	0·8
Carrots, Cabbage, and Rape	0·1	0·1		2·5			0·4
Vetches, Lucern, and Green Crops	0·1	0·2		3·0	Westmoreland	0·06	0·9
Total Green Crops	4·6	5·2	York, East Riding Cambridge Norfolk	14·1 14·2 15·1	Derby Westmoreland	3·5 2·3	7·7
Clover, Sainfoin, and Rotation Grasses	4·5	5·6	Cornwall York, East Riding	12·1 10·0	Middlesex	1·3	6·1
Bare Fallow	0·4	0·4	Huntingdon	7 0	Ditto	0·04	1·9
Total Arable Land	18·4	25·0	Cambridge	74·9	Westmoreland	10·7	38·3
Permanent Pasture	40·9	46·0	*Cheshire* Stafford Leicester Derby	46·0 47·8 59·1 57·2	Surrey Cumberland Cornwall	14·4 14·6 16·5	31·1
Total Cultivated Land	59·3	71·0	Hunts. Cambridge Leicester York, East Riding	90·1 89·5 89·5 86·7	Surrey Lancashire Northumberl'd Cumberland Westmoreland	59·1 59·3 53·3 51·6 48·9	69·4
Waste, Woods, Orchards, and Towns	49·7	29·0	Cumberland Westmoreland	48·4 54·1	Leicester Hunts.	10·1 9·9	30·6

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APPENDIX IV.

In the current number of *The Land Roll*, published by Messrs. Dowsett & Co., Lincoln's Inn Fields, London; Mr. Gilbert Murray* summarises the present Agricultural position, and compares prices in 1871 and 1891, in England.

During this period his results are tabulated as follows:—

	1871.		1881.		1891.	
	s.	d.	s.	d.	s.	d.
Average price of Wheat per quarter	56	0	47	0	32	0
,, ,, Barley ,, ...	34	0	36	0	25	0
,, ,, Oats ,, ...	25	0	34	0	18	0
Average wages of day labourer per week	12	0	14	6	15	0
Average price of Beef per lb.	..		0	7½	0	6
,, ,, Mutton per lb.	..		0	9	0	7½

Mr. Murray points that with wheat at 37s. per quarter in 1887, and only 33s. a quarter in 1871, the price of the 4lb. loaf was respectively 4½d. and 4d.; in other words, was independent of English grown wheat, and though the cost of farm labour has increased fully 25 per cent., and the best men have migrated to the towns, their absence has given a stimulus to the agricultural implement industry, and during the present harvest the cost of saving crops has been reduced at least 8s. per acre by the sheaf binder, where used; and comparing 1871 with 1891, the costs of the hayfield have been reduced about 50 per cent. by the mowing machine, the tedder horse-rake, and by loading and unloading machines.

	1871.	1881.	1891.
	Million Sterling.	Million Sterling.	Million Sterling.
Annual value of property in the United Kingdom	400	500	600
Annual value of land	48	51	41

* I am indebted to Mr. Murray, for many suggestions, especially at pp. 102, 103.

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APPENDIX V.*

Average Price of Consols for the past Hundred and Sixteen Years, with the Amount of Interest Produced.					Average Prices of Wheat, Barley, and Oats per Imperial Quarter.					
					Wheat.		Barley.		Oats.	
Years.	£	£	s.	d.	s.	d.	s.	d.	s.	d.
1785	60	5	0	0	43	1	24	9	17	8
1786	74	4	1	1	40	0	25	1	18	6
1787	74	4	1	1	42	5	23	4	17	2
1788	75	4	0	0	46	4	22	8	16	1
1789	76 3/16	3	18	6	52	9	23	6	16	6
1790	75 5/16	3	19	3	54	9	26	3	19	5
1791	82 3/4	3	12	6	48	7	26	10	18	1
1792	84 3/4	3	10	9	43	0	27	7	16	9
1793	75 3/4	3	19	2	49	3	31	1	20	6
1794	67 1/8	4	8	10	52	3	31	9	21	3
1795	65 3/4	4	11	3	75	2	37	5	24	5
1796	61 7/8	4	16	11	78	7	35	4	21	10
1797	52	5	15	4	53	9	27	2	16	3
1798	52 5/8	5	14	0	51	10	29	0	19	5
1799	60 3/8	4	18	9	69	0	36	2	27	6
1800	63 5/16	4	14	3	113	10	59	10	39	4
1801	62 1/16	4	16	7	119	6	68	6	37	0
1802	72 1/2	4	2	9	69	10	33	4	20	4
1803	61 9/16	4	17	4	58	10	25	4	21	6
1804	56 1/4	5	6	8	52	3	31	0	24	3
1805	59 1/2	5	0	9	89	9	44	6	28	4
1806	61 1/2	4	17	7	79	1	38	8	27	7
1807	61	4	18	9	75	4	39	4	28	4
1808	65 7/8	4	11	1	81	4	43	4	33	4
1809	66 7/8	4	9	8	97	4	47	0	31	5
1810	67 7/8	4	9	4	106	5	48	1	28	7
1811	64 1/4	4	13	4	95	3	42	3	27	7
1812	59	5	1	8	126	6	66	9	44	6
1813	61	4	18	9	....		....		....	
1814	67	4	9	7	74	4	37	4	25	8
1815	59 3/4	5	0	4	....		....		....	
1816	62	4	16	9	71	6	33	11	27	2
1817	73 1/16	4	2	0	96	11	49	4	32	5
1818	77 1/2	3	17	4	86	3	53	10	32	5
1819	71 1/8	4	3	5	74	6	45	9	28	2
1820	67 7/8	4	8	4	67	10	33	10	24	2
1821	73 3/4	4	1	4	56	1	26	0	29	6
1822	79 1/2	3	15	10	44	7	21	10	28	1
1823	78 1/8	3	16	1	53	4	36	6	22	11
1824	90 3/4	3	6	1	63	11	36	4	24	10
1825	84 5/16	3	10	11	68	6	40	0	25	8
1826	79 1/16	3	15	10	58	8	34	4	26	8
1827	83 1/16	3	12	2	58	6	37	7	28	2
1828	84 5/8	3	10	11	60	5	32	10	22	0
1829	89 3/16	3	6	9	66	3	32	6	22	9
1830	85 7/8	3	9	10	64	3	32	7	24	5
1831	79 3/4	3	15	3	66	4	38	0	25	4
1832	83 5/16	3	11	9	58	8	33	1	20	5
1833	87 1/4	3	8	4	52	11	27	6	18	5
1834	90 1/4	3	6	5	46	2	29	0	20	11
1835	91	3	5	11	39	4	29	11	22	0
1836	89 3/8	3	7	1	48	6	32	10	23	1

* Compiled from tables in *Whitaker's Almanac*, 1893.

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Average Price of Consols for the past Hundred and Sixteen Years, with the Amount of Interest Produced.					Average Prices of Wheat, Barley, and Oats per Imperial Quarter.					
					Wheat.		Barley.		Oats.	
Years.	£	£	s.	d.	s.	d.	s.	d.	s.	d.
1837	90 7/8	3	6	0	55	10	30	4	23	1
1838	92 7/8	3	4	7	64	7	31	9	22	5
1839	91 1/2	3	5	7	70	8	39	6	25	11
1840	89 3/8	3	7	1	66	4	36	5	25	8
1841	88 7/8	3	7	6	64	4	32	10	22	5
1842	91 3/4	3	5	4	57	3	27	6	19	3
1843	94 5/8	3	3	5	50	1	29	6	18	4
1844	98 1/2	3	0	8	51	3	33	8	20	7
1845	96 1/4	3	2	4	50	10	31	8	22	6
1846	95 1/2	3	2	10	54	8	32	8	23	8
1847	86 3/8	3	9	5	69	9	44	2	28	8
1848	85	3	10	7	50	6	31	6	20	6
1849	93 1/4	3	4	4	44	3	27	9	17	6
1850	96 5/8	3	2	1	40	3	23	6	16	5
1851	97 3/4	3	1	4	38	6	24	9	18	7
1852	98 3/4	3	0	8	40	9	28	6	19	1
1853	95 7/8	3	2	6	52	3	33	2	21	0
1854	90 1/2	3	6	3	72	5	36	0	27	11
1855	90	3	6	8	74	8	34	9	27	5
1856	90 3/4	3	6	1	69	2	41	1	25	2
1857	90 3/4	3	6	1	56	4	42	1	25	0
1858	96 3/8	3	2	2	44	2	34	8	24	6
1859	92 11/16	3	4	8	43	9	33	6	23	2
1860	94 1/8	3	3	8	53	3	36	7	24	5
1861	91 3/4	3	5	4	55	4	36	1	23	9
1862	93 1/4	3	4	4	55	5	35	1	22	7
1863	92 5/8	3	4	9	44	9	33	9	21	2
1864	90 7/8	3	6	6	40	2	29	11	20	1
1865	89 1/2	3	7	0	41	0	29	8	21	10
1866	87 7/8	3	8	3	49	11	37	5	24	7
1867	93	3	4	6	64	5	39	11	26	0
1868	93 7/8	3	4	0	63	9	43	0	28	1
1869	92 7/8	3	4	7	48	2	39	5	26	0
1870	92 1/2	3	4	10	46	11	34	7	33	10
1871	92 3/4	3	4	8	56	8	36	2	25	2
1872	92 1/2	3	4	10	57	0	37	3	23	2
1873	92 1/2	3	4	10	58	8	40	5	25	5
1874	92 1/2	3	4	10	55	9	44	11	28	10
1875	93 3/4	3	4	0	45	1	38	5	28	8
1876	95	3	3	2	46	2	35	2	26	3
1877	95 3/8	3	3	0	56	9	39	8	25	11
1878	95 3/16	3	3	10	46	5	40	2	24	4
1879	97 1/2	3	1	6	43	10	34	0	21	9
1880	98 3/8	3	1	0	44	4	33	1	23	1
1881	100	3	0	0	45	4	31	11	21	9
1882	100 1/8	2	19	8	45	1	31	2	21	10
1883	101 3/16	2	19	2	41	7	31	10	21	5
1884	101	3	0	2	35	8	30	8	20	3
1885	99 1/8	3	0	2	32	10	30	1	20	7
1886	100 1/2	2	19	8	31	0	26	7	19	0
1887	101 1/8	2	19	0	32	6	25	4	16	3
Reduced to 2 3/4 per cent.										
1888	97 11/16	2	16	4 1/2	31	10	27	10	16	9
1889	98	2	16	3	29	9	25	10	17	9
1890	96 1/2	2	17	3	32	2	27	10	18	4
1891	95 1/2	2	17	7 1/2	32	4	....		18	4

1846, Sir Robert Peel's C rn Law Bill.

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On the motion of Mr. Stirrup, seconded by Mr. Dickinson, the thanks of the meeting were given to Mr. De Rance for his paper.

Professor DAWKINS, who was invited by the Chairman to say a few words, said: I have nothing to say with respect to this very valuable communication. I should, however, like to have heard in it something that would have given the farmers a little better heart than they have at the present time, and under present conditions, I fear we can hardly look forward to any particular climatic change which will allow of their competing successfully with those regions where the production of corn is of such enormous extent, and where the climate is so steady and regular. I think the method of inquiry pursued by Mr. De Rance is very important. I welcome it, more particularly from the point of view of physical geography. I think the geological aspect of agricultural questions is quite novel, and is of extreme interest. I have listened to the paper with the greatest pleasure.

Mr. STIRRUP: I think the paper goes to show the intimate connection there is between the geology of a country and the well-being and prosperity of its people. For instance, the permeable or impermeable character of the rocks is a factor in the consideration of the healthiness of any district, and one which every officer of health should take into account when he comes to deal with the districts of a town, where the composition and structure of the underlying strata vary. One circumstance came under my notice the other day—that was the immunity which the district of Northwich is said to enjoy from zymotic diseases. Whether that is due to the salt-boiling carried on there I do not know; probably the salt fumes act as an antiseptic. Perhaps Mr. De Rance or Mr. Dickinson will be able to say whether the health of the people is affected favourably by such an occupation?

Professor DAWKINS: I would like to ask Mr Stirrup if it is really a well-ascertained fact that there are no zymotic diseases in Northwich?

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Mr. Stirrup: I was asking for information on that point. I have heard it stated and have also read that it is so. I thought Mr. De Rance or yourself would be better acquainted with the district than I am. But I feel quite convinced that the character of the subsoil in any district has a great effect on the healthiness of the population. Of course, a good system of drainage remedies the probable ill effects of habitations built on heavy clays or impermeable soils.

Mr. Dickinson: I said in one of my reports to Government that in Northwich, in consequence of the sinking of the ground, the sewers have been much interfered with; and that apparently it would be better not to make them so deep. When the Platts Hill mine became inundated in December, 1880, water and mud were thrown up like geysers, and the smell given off was like that of the smoke from burnt powder, or stagnant sewage. That cannot be a very healthy subsoil; but the fumes from boiling the salt seem to produce good health, and a more healthy-looking body of men than the rock-salt miners I think you will not find anywhere.

Mr. De Rance: Would not the smell referred to be the stale atmosphere from the disused mines?

Mr. Dickinson: It may have been. It was like old powder smoke.

Mr. De Rance: I may say, as regards diseases, that it is quite certain that Northwich has enjoyed an immunity. A rather curious set of circumstances occurred there many years ago, but within the memory of existing inhabitants of the town certain prominent ratepayers formed a private company, without an Act of Parliament, for supplying the town with water, and the company got its supply by pumping from Wade Brook. After a time it was decided to improve this supply, or to increase it; but during the whole of the time that water was supplied

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by this company, acting without the authority of Parliament, there was no case of zymotic disease in the township of Northwich. But on the opposite side of the River Weaver is the suburb of Castle Northwich—a separate parish—and there the Local Board, which came into existence after the company was formed, erected a little waterworks, and in that district cases of typhoid fever have occurred, but whether they were supplied by these works, I do not know; but I believe I am correct in saying that there has been no typhoid fever in Northwich proper. The water company, finding that they had no power to cut up the roads, and wanting to improve their supply, went to Parliament for powers. Then the Local Board stepped in and said, "No, you shall not do that; we will have a water supply of our own." So they obtained a Bill to take water from Cote Brook, which, in my opinion, is not equal to that which the company had already to hand; and that is the state of things existing now. Whether the immunities they have experienced will continue, remains to be seen; but, as has been stated, there can be no doubt that a salt atmosphere is a remarkably healthy one, and a more healthy lot of people than the salt miners, as Mr. Dickinson said, you could not see. There must be something peculiar in the atmosphere, because you see children playing about the streets, whose abodes are in the side courts, where no direct sunshine can penetrate, who are yet healthy looking. I think it is due in great measure to the saline atmosphere.

The CHAIRMAN: Is it supposed to arise from the manufacturing process?

Mr. DE RANCE: During the manufacturing process vapours arising from the boiling are wafted through the district.

Mr. STIRRUP suggested that further discussion upon the paper should be postponed until it had been printed in the Transactions.

The suggestion was supported by Mr. Dickinson, and agreed to.

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HOW, AND WHAT TO OBSERVE IN AND ABOUT MINES, WITH SOME PRACTICAL TESTS.

By Mr. James Grundy, H.M.I.M.

It has been well said that "Man can produce no effect upon nature, or appropriate her powers, unless he is conversant with her laws, and with their relations to material objects according to measure and numbers. And in this lies the power of popular intelligence, which rises or falls as it encourages or neglects this study. Science and information are the joy and justification of mankind. They form the springs of a nation's wealth, being often indeed substitutes for those material riches which nature has in many cases distributed with so partial a hand." "All great practical discoveries are the result of much study, the exponent of a long series of observations, and often arise out of those truths of science which appeared least promising on their first announcement." "Practical, like abstract science, has no limits." When these statements were made, many years ago, they appeared to be self-evident truths, because the examples available for proofs were great in variety, important in their applications, and were visibly leading to still greater results. To-day the examples of the wonderful, and highly beneficial applications of abstract science, and of a form that at first appeared to the majority as mean and unimportant, is quite overwhelming. Such great advancement has been recently made, so much has been done, and in fact is being done to spread wider and wider, and higher and higher, the practical branches of the ever-growing theoretical scientific tree of knowledge, especially in chemistry, and in physics, that it is quite impossible to obtain, much less to keep, a full memory record of the

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advancing scientific demand. The way out of this difficulty is to "specialize," but in a somewhat broad sense, for to specialize narrowly is one of the least desirable things to do. When the domain has thus begun to bear traces of boundary marks, and the somewhat limited area is surveyed, it is found that after all that has been done, there is very much still remaining to be done; that many subjects of the highest value, both in theory and in practice, have, to put it in the mildest form, had less than their reasonable share of attention. One can well imagine the feelings of the founders of the Manchester Geological Society, when, imbued with the highly important part that mining and geology were destined to take in the prosperity of the nation; and of the responsibility and claims they exact, this excellent Society was established, to undertake the special work of collecting and diffusing practical and theoretical knowledge respecting geology and mining. Though the objects of the Society may in some sense be looked upon as special, yet the scope is large enough indeed, it is daily growing and enlarging its borders; and I think there can be little doubt that from several points of view it is unequalled in importance. This expanding scope means more work, and, consequently, more workers if we are to keep abreast in this friendly race of doing good, a race in which there is plenty of room for all to take a part. The Society has not yet lagged behind, but has kept pretty well to the front, and it is to be hoped that its position in the future will be more than sustained by each and every member putting his hand to the plough, to cut the furrows deeper and longer as opportunity serves, to increase the sum of human knowledge, to the advancement of our industries, and the annihilation of their dangers. Many matters are brought before the Council and the Society, from time to time, the investigation of which appear to be

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of the highest importance both to mining and to geology, but, apparently, the interest is not kept up to the desired fulness of life and vigour. As an instance, it will be well known to all the members, and was referred to in the last report of the Council, that the Society has, for some time past, been attempting to make a systematic collection of the fossils to be found in the coal fields of Lancashire, and the adjacent counties; with the object of recording their distribution and order of occurrence. Certain difficulties have been met with that have hindered the work going on as fully as the Council believed it reasonably might; it was, therefore, resolved upon to make a special effort to advance the work, by enlisting the aid of all parties who are in a position to help in the smallest extent, no matter whether members or not; by making known, as clearly as possible, the kind of help that is required, and by lightening the labour as much as that can be done. In connection both with this subject, and other special work, it has been thought that possibly a want was being felt of some definite mode of procedure being set out, so that members, and others, would know exactly what it was best to do, and how best to do it. With this in view, I have, at the special request of our worthy Honorary Secretary, made an attempt to draw up and indicate some suggestive details with reference to several subjects of the Society's work, in the hope that they will be found to some extent helpful to those who may be willing, and have opportunities, to help on the work; and be the means of increasing the number of observers, to the benefit of themselves, the Society, and the community generally.

1. Fossils.—During the last two Sessions important subjects bearing on the *exhaustion of the coal seams* have been brought before the Society on several occasions, both by papers and discussion, and means have been suggested

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for the alleviation of the future difficulties that appear likely to arise, as well as to put off the evil day to a more remote period than has often been indicated. Although the time when English coal will have been all consumed may not be very near at hand, a few years time may find many of our thriving and populous mining districts struggling with the difficulty; the best coals worked out, collieries closed, at least for a time, the inferior coal remaining to be got out being quite unable to bear the strain of competition, and most surely the paralysis of other industries following in its train. It appears that one of the most important ways of meeting the coming difficulty, is to get as thorough a knowledge of the carboniferous and adjacent strata as is possible; to get as near as possible to that state when no matter what part it may be decided upon to explore the exact geological position could be correctly arrived at. There can be few better ways of approaching this desirable condition of geological knowledge than an extended and closer study of carboniferous fossils; and if the sole object was to provide for the somewhat distant future, it is quite a sufficient reason for the Society taking the subject in hand, with seriousness and energy, so so far as relates to our own coal field. But this is not all, there is a present and pressing want of such information as it is hoped this work will provide; coal seams are being rapidly cleared out, and new seams have often to be searched for, owing to the very doubtful and faulty nature of the ground; and it is too well known that seams are often lost, at least for a time, long before they are worked out, owing to the intervention of a large fault; or it may be that a single small fault in one part is much larger at another part, may have changed considerably in direction, and may have unexpected branch faults springing from it, varying both in linear direction and in direction of throw. In all

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such cases it would be of great assistance, and would often save large sums of money, if the different seams and strata could be fully identified, and to this end a knowledge of the characteristic fossils would be of the greatest assistance. In order to get this work accomplished it is quite necessary that at least all those members who are in a position to help should willingly co-operate to carry it through; the work is great, but we trust to the good will of the members, and others, to provide against the labourers being few. The facilities and ability for collecting fossils no doubt vary greatly, but everyone may to a greater or less extent become collectors. To prevent any misgiving in the matter, I may say that for the purpose of the objects for which the Society wants the fossils, it is not at all necessary that the collector be an expert palæontologist, or even have much knowledge of any branch of geology; all that is required for this purpose is that fossils be collected and carefully preserved, and a note made of the bed or stratum where found, and of the name of the pit and locality. The fossils should then be sent to the Hon. Secretary, the Geological Society's Rooms, 36, George Street, Manchester. They should be carefully packed, wrapped in paper singly, and have the particulars of where they were found accompanying each set. When sending the fossils, the sender is quite at liberty to send them either with or without prepaying the carriage; but it would be well to advise the Secretary that they are being sent. In describing the positions in which they are found, it will perhaps be best when referring to the vertical position to give the relative position to some well-known seam or stratum; and for the geographical position to give the name and situation of the colliery, or relative position to a town or village or other well-known landmark, or the latitude and longitude of the place, if they be available. It is highly desirable, in fact it is of the greatest importance, that the

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fossils be sent just in the state in which they are found, unless the adhering refuse is of a bulky form, therefore, they need not be cleaned, and no attempt should on any account be made to cover them with any supposed preservative. If a part of a fossil be covered with some of the accompanying rock no attempt should be made to chip it off if there is the least risk of damaging the fossil, experienced and trained hands will be best able to take off what is thought to be necessary; but a fossil should not be kept back because it is damaged, for there will probably be more of these than perfect ones, and each part will tell its own tale and may supply the much needed missing link in a series. Again, it is not at all necessary to name the fossils, unless the sender wishes to do so. It will be seen that this is a work in which we can all take a part, and I am sure the Society will fully recognise and acknowledge all the contributions from whatever source they may come. It should be noted that the above remarks apply both to fossils that may be given to the Society, and those sent on loan; if lent only, it should be so stated at the time the fossils are sent, and I think the sender may rely on the care that will be bestowed on his property, and on his wishes being carefully respected.

Detailed Sections.—Closely connected with this subject, and of the very highest importance both for the present and the future, is the making of detailed sections of coal seams and the adjacent strata. Mr. W. S. Gresley has given us a good example of what it is possible to do, in this direction, in his paper published in Part XVII. of Volume XXI. of this Society's Transactions. It is an example well worth imitating either for private or for public use, and would be most beneficial in the identification and correlation of seams. Although no two characteristic sections from the same coal might fully correspond, yet they would be sure to have so many points in common that

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they would be an invaluable addition to the observations on strata so frequently made.

2. The Thermometer.—Much useful work could be done with a good thermometer in taking temperatures in mines, and without much expense or much extra labour. A good and extensive series of observations made in mines of varying depth, and covering a large area of country, would be of great geological usefulness, and even a few good sets of observations might be valuable We find it set out in text books that the temperature of the earth increases, as we descend, at the rate of about 1° Fahr. for every 60 feet increase in depth, below a certain depth which is sometimes called the zone of invariable temperature; and those figures are accepted as being so near the truth that attempts have been made to apply them to practical working, and such important calculations and theories as arise from speculations on the internal heat of the earth have been based on the above figures. Now it is probable that the figures are based on an insufficient number of observations, and a want of variety of circumstances, and that it may be far from correct to assume that because the temperature increases with this rate of descent at some parts it does so at every other part, an assumption which if not strictly true leads to many false calculations being made. There appears to be sufficient chemical action going on in the earth to make a uniformity of temperature at a given depth very unlikely, and this has been borne out by many actual tests in mines. It is well known that the temperature of coal seams vary greatly at the same depth, some being comparatively cool while others are warm, the Doe seam being a good example of one that is almost always warm; and there are good reasons for believing that the high temperature is the result of chemical action going on in the strata and debris of the mine.

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It is stated in Jukes' "Manual of Geology," that from the observations of Mr. Henwood in the slate rocks of 200 mines in the counties of Cornwall and Devon, it was found that at a depth of 300 feet the temperature was 57° Fahr., at 600 feet 62°, at 900 feet 68°, and at 1,200 feet 78°, the temperature in the granite rocks not being quite as high. These figures give an increase of temperature of 1° Fahr. for an increase in depth of 60 feet, 50 feet, and 30 feet respectively, this latter figure showing a fast increasing temperature quite out of the range of the commonly accepted figures. Again, when a pair of pits, at the Rose Bridge Colliery, near Wigan, were being sunk from about 600 yards deep to a little over 800 yards deep, observations on the temperature of the strata were frequently made. Holes were drilled three feet deep in solid ground, and the thermometer was put in the holes and allowed to remain in for at least 30 minutes, and the results varied greatly. Out of 12 observations eight of them gave an increase of 1° Fahr. for less than 50 feet of depth, the two extremes being 1° Fahr. for 24 feet and 110 feet respectively, the average being 1° for 48·2 feet, and many other examples might be given. When making temperature observations a good mercurial thermometer should be used, and a large number and variety of tests should be made; such as in the coal, and in the rocks when convenient; holes being bored three or four feet deep to receive the thermometer, or a pair of thermometers that would indicate the maximum and minimum temperatures. The temperature of water issuing from roof, floor, sides, coal, or old works would also be included in the observations.

3. The Barometer.—There appears to be a great want of confidence as to the value of barometric observations, except as being in some way an indicator of the approaching weather; yet we have had about five years compulsory

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experience of it in connection with mining, and we are frequently presented with newspaper warnings based on barometric readings. Ought we not to take immediate steps to find out the real value of the barometer as an indicator of dangers to be avoided. I might suggest that one of the practical ways of doing this would be for a number of persons intimately connected with collieries to keep the records of a self-recording barometer of a good make, and at the same time arrange for the many and varied changes that take place in mines being as far as possible noted and compared with the barometric readings. The observations and records would include falls of roof and sides, unusual appearances of fire-damp, or black damp. They would also be of great service in the solution of the problem as to what extent the weighting and unexpected falls of roofs, sides, or coal, as well as the issue of gas from them, and from the goaf, are affected by the changes in the atmospheric pressure. If some of the owners and managers of mines would begin this valuable work they might count on the fullest assistance being given by the Council, and a system upon which these records could be best kept might be arranged. It does not follow that the particulars of falls and issues of gas should be made public, the results only would be required for comparison; and I am sure that with a little co-operation the thing could be done in a way that no one could reasonably object to. Another matter worth investigation, is the changes, if any, in the quantity of air circulating in the mine; or the relative value of the air for ventilating purposes, during the varying atmospheric pressures. This work would probably well repay the doer of it, whether the results were made public or not. I have here a convenient form of self-recording aneroid barometer, kindly lent to me, for this meeting, by Mr. Joseph Casartelli, of 43, Market Street,

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Manchester. Its cost is £6 10s. It requires winding up, the charts changing, and the pen filling with ink once for seven days working; this only takes a few minutes, and then the instrument will go on again for another week without any further attention. It will be noticed that it gives a good bold continuous diagram showing the barometric pressure at the place of observation, during every moment of the day and night, forming a permanent record of all the variations of pressure. I believe that at some collieries these records of pressure, made by their own aneroid, are kept, and if they could see their way to adding such records as are here sketched out, I believe they would find it to be a valuable addition.

Mr. Casartelli has also kindly lent me, for the members to see, two ordinary thermometers of convenient form; a maximum and minimum thermometer, and one that is both maximum and minimum; also a hygrometer, an instrument too little used, for by its use the humidity, dew point, &c., of the air can be readily ascertained by referring its readings to a series of tables contained in these small books on the table. And there is also on the table a watch form or pocket anemometer, that appears to be handy to carry into the workings, and convenient to use.

4. Underground Water.—Investigations on water in mines gives scope for much useful work, and much that is of importance practically, as well as from a geological point of view. Temperature observations on water have been already referred to. Then there is the saltness of water. The quantity of common salt in mine waters appears to vary greatly with the geographical position of the mines, some waters being very salty, and others containing too little to be perceptible to the taste. It would be valuable to know to what extent this saltness is due to any particular and prevailing strata; and to what

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extent this is influenced by the depth from the surface of the part from which the water issues. In the neighbourhood of Wigan, for instance, which is adjacent to the triassic rocks, the waters of many of the mines contain a large quantity of salt. There is also the acids, and dissolved metals that are frequently found in mine waters, as well as their effects on the pumps or other iron and brass materials; these may also give indications of the nature of the ground through which the water has drained. It may be useful to describe briefly the way that a few qualitative chemical tests can readily be made on any sample of water, so as to be able to tell whether certain substances are present, and with a little practice be able to say whether they are present abundantly. The necessary apparatus need not be more than a packet of test or litmus papers; about a dozen small test tubes; an ounce bottle of silver nitrate *solution;* and small bottles, say 4 ounces of the other *solutions* referred to; the whole could be got from most chemists at a moderate cost, but Messrs. Woolley, of Market Street, Manchester; or Mr. Mason, of Derby Street, Bolton, would make them up in a most convenient form.

Tests.—1. For acidity of solution. Wet a blue test paper with the water to be tested, and if it changes colour to red then the water is acid; if it does not change colour, then wet a red paper with the water and if it changes to a blue colour the water will be alkaline, but if it does not change colour the water will be about neutral. Note.—If the water does not show acid by this test it *cannot* contain any free acid. If the water does not show acid it will *not* be likely to contain any carbonic acid or carbonates, except it should happen to be acid by the quantity of carbonic acid it contains.

2. Carbonates, limestone, chalk, marble, &c., either in solid

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state or solution. On applying *hydrochloric acid* to any of these an effervescence is set up and carbonic acid is given off.

3. Sulphuric acid as a sulphide or sulphate. Put a little of the water in a test tube, then add a little *barium chloride* solution. If a white finely divided precipitate is produced it indicates presence of this acid. A few drops of *hydrochloric acid* added, also, would help the reaction. NOTE.—A solution may contain this acid in combination without showing acid to test paper. Again, if a little *methylated alcohol* be added to water or any other solution containing a sulphate, a finely divided precipitate will be formed, because there are no sulphates soluble in alcohol.

4. FREE SULPHURIC ACID.—If the water shows acid to test paper, then to test whether it is due to this acid proceed as follows:—Put a little cane sugar in an evaporating dish, or an ordinary saucer will do very well, add a very small quantity of the water to be tested, then put the saucer over a small pan of boiling water, and when the sugar solution is evaporated to dryness the sugar will be left as a black charred mass if free sulphuric acid was present. No other acid can decompose cane sugar like this.

5. IRON.—This may be in the water either in one or both of two states, namely, the ferrous and the ferric states. NOTE.—Several tests may well be made for iron, and for each a clean test tube should be used and a separate quantity of the water to be tested; about 1½ inches of the water in a tube is quite enough for a test. Test for *ferrous iron*—add (*a*) *Ammonia*, if the iron is present a white precipitate will be formed which will soon change to a green colour, and if allowed to stand it will become reddish-brown; (*b*) add to another portion of the water a little *potassium ferricyanide solution*, and if the iron is present a dark blue precipitate, called "Turnbull's blue," will be formed. If a little *hydrochloric acid* be also added the formation of the pre-

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cipitate will be more certain. This test is one of the most characteristic tests for ferrous iron. Test for *ferric iron*—If iron in this state is present (*a*) the addition of *ammonia* gives a foxy-red precipitate; (*b*) the addition of *potassium ferrocyanide solution* gives a fine blue precipitate called "Prussian blue." A little *hydrochloric acid* assists the formation of the precipitate. This also is a characteristic test; (*c*) if the water contains only a very small amount of this iron the addition of *ammonium sulphocyanide* will cause it to change to a red, dark red, or blood-red colour. The addition of a little hydrochloric acid is advantageous, in many cases.

To change all the iron in solution into the ferric state. If this is desired, add a very little *nitric acid* to that portion of the water that is to be tested for iron, and boil it, either over a spirit, or Bunsen flame, or on a sand bath until it becomes of a yellow colour; the iron will be thus oxidized to the ferric state, and can then be well tested for in that form. When water forms a deposit of ochre there can be little doubt as to the presence of iron.

6. Common Salt, and Hydrochloric Acid.—If the water contains much salt it will be perceptible to the taste, and a good judgment can be formed as to the degree of saltness. If these substances are present in the water, the addition of a very few drops of *nitrate of silver* solution will cause a white curdy precipitate to be formed, which will turn violet by exposure to light. (This principle is used in photography.) If the precipitate does not readily form, it would be well to add a little *nitric acid.*

7. Sulphuretted Hydrogen.—If this be present in the water the addition of a little *lead acetate* solution will give a dense black precipitate, with a shining metallic film on the surface.

8. Some water has a corroding effect on iron, some has the same effect on brass, and other water acts on both, as

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many a steam user knows to his cost. A simple and useful test that would give practical information, would be to half fill two small bottles with the water; in one put a piece of iron, and in the other put a piece of brass, the metals in both cases being half in and half out of the water, and the effects noted. This test could well be varied by having a greater number of small bottles, with which to test various qualities of iron; and also by using a large test tube instead of a bottle, the tube to be put in a hot place, and the water kept replaced as it evaporated; and also by having a piece of iron and brass in contact, and in the same water.

If it be desired, I should be glad, at a future meeting, to give further particulars as to making these tests, or to show some of the tests of a pit water.

In conclusion, I may say that the foregoing only refers to a few of the many important matters that require more willing workers to bring to a satisfactory condition. As an instance, I need only refer to the highly important and allied subjects of *explosives and explosions*, with respect to safety, health, and economy. There may be another opportunity, at some other time, to again refer more fully to these subjects; but, in the meantime, I should like to direct attention to a new book just purchased by the Society for the use of members, which gives the result of M. Berthelot's continued investigations on explosive substances since the year 1870. M. Berthelot's scientific reputation is very great indeed, and the results of his labours, as given in the English translation referred to, cannot be over-estimated. In this connection I will venture the opinion, that so soon as we gain a correct knowledge of explosives and explosions, we shall be within easy reach of practical preventive remedies, and I do not know of any better preparation, for anyone who may be wishful to attain to this condition, than a careful study of the work of this great French investigator.

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ADDENDUM.

After the reading of the foregoing paper, Mr. Joseph Dickinson, late Chief Inspector of Mines, expressed an opinion that some additional tests, for a greater variety of minerals, and some that could be readily applied and be useful, in connection with metalliferous mining, would be a valuable addition. Valuable and available minerals are often neglected because, in the absence of tests and want of familiarity, they are not recognised; and cases have been known where mineral wealth has been thrown into the refuse heap. On the other hand, minerals of little value have been mistaken for precious metals, and given rise to hope, excitement, and expense, and ended in disappointment. The effect this has on the mineral industry is far from good; for the mineral resources of the country are not in proportion to the quantity of mineral contained in the earth, but more in proportion to the quantity *known to be there;* and this knowledge can be extended by intelligent observation and tests. The following are offered as suggestive, but easy and reliable, preliminary tests that can be readily made on any substance:—

Preparation of Substance for Testing.

1. *If the substance is a liquid.*—Put a very small quantity of it on a clean watch glass, or any thin glass, or porcelain dish; place it on a sand-bath and evaporate to dryness; if there is no residue it indicates absence of metals; if there is a residue, it can be tested in a flame, or before the blowpipe, or by any other *dry* test. More of the liquid might be evaporated to get more residue, if desired. The liquid would be tested by re-agents, in the *wet* way, as described further on.

2. *If the substance has a metallic appearance.*—Note whether it is malleable in addition to having a bright lustre,

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if so, it is certainly a metal; but if it is brittle it may be a mineral compound. *If it is a metal*, put a few small fragments into a test tube, or small beaker, add a very little water, and then a little strong nitric acid; and *if it dissolves* by this, add three or four times its volume of water and test the solution. *If it does not dissolve*, boil it in the acid over the sand bath (*keep from the acid fumes, they are poisonous*), if it then dissolves add water and test. *If it does not dissolve* by this treatment, dilute the acid by about twice its volume of water and boil again. *If it is still insoluble*, put a filter paper in a glass funnel supported over a beaker, and pour the whole solution and substance on the filter. Wash the residue on the filter with two changes of clean water, and note what happens when a little ammonium sulphide is poured over it. *If it turns slightly yellow*, it is a tin compound; and if a little of the original substance be heated on charcoal, before the blowpipe, it should give an easily fusible, malleable globule, and form a white incrustation on the charcoal. *If it turns to orange colour*, it is antimony, and when similarly heated on charcoal it should give a brittle globule from which white fumes rise, and form a white incrustation. *If it turns black* it is galena, lead; and if some of the finely powdered substance be boiled with strong hydrochloric acid, then diluted with water, it can be tested in solution for lead. *If the substance is unacted upon* by the above treatment, it will probably be either gold or platinum; and in either case it will dissolve in aqua regia (*aqua regia* is made by adding one part strong nitric acid to three or four parts of hydrochloric acid); if it is gold, it will be yellow, malleable, soft, can be cut with a knife; if it is platinum, it will be white, and have its other properties. The solution formed, by dissolving in aqua regia, can be diluted with water and the solution tested.

NOTE.—All substances should be first carefully examined

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by the eye, and with the aid of a magnifying glass in most cases, as well as by other simple tests, which often tell a great deal. For instance, native gold has the characteristic of presenting the same colour from whatever direction it is looked at; it can be hammered out, and also cut into slices; but those substances which are likely to be mistaken for gold are reduced to a powder when hammered. Iron pyrites cannot be cut with a knife. Copper pyrites forms a greenish powder when hammered. Pyrites ores when heated give off a sulphury odour. Again, a speck of gold is not altered in colour or appearance by hydrochloric acid.

3. *Solution of a solid substance which has not a metallic appearance.*—Break the substance and reduce it to a very fine powder. This may be done in a mortar, or by wrapping it in folds of clean paper and striking with a hammer on some hard surface. If heat is not likely to injuriously affect the test, many substances may be readily reduced to powder by making them very hot and then putting them into a clean vessel of cold water.

Boil a little of the powdered substance with clean water, either in a test tube or in a beaker, and on a sand bath. *If the substance is entirely dissolved*, filter off any suspended particles of dirt if necessary, and begin to test solution. *If it is only partly dissolved by the water*, then allow the particles to settle to the bottom, and carefully pour off the liquid into another vessel; add more water to the residue and boil again; and if it now entirely dissolves, add the two solutions together and test. *If it does not dissolve*, then either pour off the greater part of the liquid and use the residue, or take a fresh portion of the original substance and moisten it with a little water; add a little hydrochloric acid, and if this does not dissolve it, boil the mixture. *If this does not dissolve it*, take a fresh portion of the substance and add a little *strong* hydrochloric acid, and heat to boiling. If it is

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now dissolved, add to solution twice its bulk of water and test; but if the addition of water causes a precipitate to form, test the precipitate for lead and silver; then warm the liquid and add strong hydrochloric acid drop by drop until it disappears. If the substance appears to be acted upon by the foregoing treatment, but there is a residue left differing in appearance to the original substance, then the residue should be allowed to subside, and the liquid poured off and diluted with twice its bulk of water and tested; or the water may first be added, and then the solution be filtered. The residue left in this case may be neglected.

If the substance is unacted upon by strong hydrochloric acid, then add a very little strong nitric acid to the strong hydrochloric acid solution (this forms aqua regia), and boil the liquid, in a position where the poisonous fumes will be taken away. If the substance dissolves, boil until no more chlorine is given off, dilute with water and test. *If substance is still undissolved*, boil a fresh portion of it with dilute nitric acid, and if dissolved, test. *If not dissolved*, boil a portion with strong nitric acid, and if a clear solution is now obtained dilute it with water and test. *If the substance is insoluble in water and acids*, then mix some of the very finely powdered substance with about four times its weight of fusion mixture, place the mixture on a piece of porcelain, and heat strongly over gas blowpipe flame, or, with care, over a smithy fire until all action is over and the mass is in a state of calm fusion. When cool, grind it with a little water in a mortar, put it into a beaker with more water and boil; if it does not dissolve, add a little hydrochloric acid and boil again to complete the solution, and test. Almost every known mineral substance can be brought into solution by the foregoing methods, and they have been dealt with so fully, because to get a substance into a suitable condition for some tests is by far the most difficult part of the test.

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Fusion mixture.—This consists of carbonate of soda and carbonate of potassium, mixed in the proportion of about 10 to 13. Carbonate of soda, by itself, is also a good reagent for blowpipe reactions. An excellent reducing agent is potassium cyanide; and for the blowpipe, either a mixture of equal parts of potassium cyanide and carbonate of soda, or potassium cyanide and fusion mixture, make most excellent reducing mixtures.

A sand bath.—This is a common, shallow tin vessel, filled with dry sand, and may be heated by any source of heat that can be kept under control, and is most convenient and safe, for boiling and drying substances, and for concentrating liquids by boiling off some of the water.

Tests.—The most convenient, simple, and quickest tests are those that can be made on most minerals with very little preparation, by means of an ordinary Bunsen's flame, and with a blowpipe flame. These tests include flame colour tests; characteristic beads with various fluxes, both by oxidation and reduction; reduction to metal, incrustation, &c., on a piece of charcoal; fusion, sublimation, films, and reduction to metal in open glass tubes, and in bulb tubes, so that a great variety of tests can be made by these methods in a very short time. The value of these tests will be appreciated from the fact that with a piece of charcoal, a little of one of the reducing mixtures already described, and a blowpipe flame, gold, silver, copper, iron, nickel, cobalt, lead, bismuth, antimony, or tin can be obtained as metal when present in a substance; also mercury and arsenic, but these at once volatilize; and cadmium and zinc, but these at once oxidize. To manipulate the blowpipe to advantage requires a little practice, and a knowledge of the properties of the different parts of the flame and of the kinds of flame that can be produced. Anyone may gain the practice, the necessary apparatus being of little cost; and for clear and

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concise instructions on the various flame and blowpipe, or dry tests, and on wet tests, the two following books can be recommended, viz.:—"Jones's Junior Course of Practical Chemistry," 2s. 6d.; publishers, Macmillan and Co., London. And "The Prospector's Handbook," by J. W. Anderson, 3s. 6d.; publishers, Crosby, Lockwood and Son, London. But there are a great many other good books on the subject.

9. *Silver.*—This *metal* is dissolved by nitric acid, and also by sulphuric acid, if heat be applied; but hydrochloric acid has very little action on it: air and water have none. Sulphur combines with it to form a black compound. Note.—The properties of substances should be taken advantage of for the purpose of confirmatory tests. If a small quantity of a silver compound be mixed with twice its amount of bicarbonate of soda, and put in a small cavity made in a piece of charcoal, and strongly heated in the reducing flame of the blowpipe, bright globules of metallic silver are formed, which can be collected, dissolved, and tested, as below.

If hydrochloric acid be added to a solution containing silver, a white curdy precipitate is formed. This silver precipitate is *soluble in ammonia.* If exposed to light it changes colour to violet. Confirmatory.—If potassium chromate be added to a solution containing silver, a dark red precipitate is produced, which can be dissolved by hot nitric acid, but on cooling again needle-shaped crystals are formed.

It may often be advisable to dry a portion of a precipitate and test it by flame tests.

10. *Mercury, or Quicksilver.*—This metal may be in solution in one or both of two forms, namely, the mercurous and mercuric. One form is soluble in dilute hydrochloric acid, but the other is not; therefore, hydrochloric acid added to a solution containing mercury in one form will

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give a white precipitate. This precipitate is insoluble in dilute acids; and, unlike the silver precipitate, it is *insoluble in ammonia*, but is blackened by it. Confirmatory.—If tin chloride (stannous chloride) be added to a solution containing mercury in this form, a grey precipitate of mercury will be produced; and if the liquid be poured off and the residue boiled with hydrochloric acid, distinct globules of mercury are obtained. Again, if a piece of clean, bright copper be wetted with a neutral or only slightly acid solution containing these mercurous substances, a stain of metallic mercury is formed which becomes bright on rubbing, but disappears when heated. Tin chloride (stannous chloride) added in small quantities to a solution containing mercury in the other or mercuric form gives a white precipitate; but on adding an excess of stannous chloride, metallic mercury precipitates as a grey powder, and may be united into a globule by boiling with hydrochloric acid. Flame tests can also be made.

11. *Lead.*—This metal oxidizes superficially on exposure to air or water. It is easily dissolved by nitric acid and by acetic acid; but sulphuric and hydrochloric acids are practically without action on it. Most lead compounds, except the nitrate and the acetate, are insoluble in water. It is of a bluish colour, very soft, and leaves a mark when rubbed over paper. A little powdered lead compound, or a dried precipitate, mixed with bicarbonate of soda and heated on charcoal in the reducing flame of the blowpipe, gives malleable metallic beads which have the characteristics of the metal. These beads can be dissolved and tested in the wet way, thus forming a confirmatory test. The wet and the dry reactions should be made confirmatory to each other. Hydrochloric acid added to a lead solution gives a white precipitate, which dissolves again on boiling, but on cooling again fine needle-like crystals are formed. *Ammonia has no*

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action on this precipitate. If the solution contains very little lead the precipitate will not readily form, therefore it may be necessary to concentrate the solution by boiling off some of the liquid to be tested.

Confirmatory.—Potassium iodide, added to any lead solution, produces a bright yellow precipitate, which is soluble in boiling water; but on cooling again, brilliant golden scales are formed in the solution. Hydrochloric acid does not precipitate lead in all its compounds; therefore it would be well to make the potassium iodide test in all cases. Sulphuric acid, added to lead solutions, gives a white precipitate which is insoluble in cold dilute acids.

12. *Copper.*—Has a decided red colour. On exposure to air it oxidizes at ordinary temperatures, and rapidly when heated to redness. Water has no action on it at any temperature; but most acids attack it, especially if it is exposed to the air at the same time. Alkalies, including lime and ammonia, also act on it. It is hardened by being pulled, or hammered, or any similar treatment; and is softened by heating to redness, and sudden cooling as by plunging into cold water.

Compounds of copper, when moistened with hydrochloric acid and heated in a Bunsen flame, colour the flame green. A little powdered compound mixed with bicarbonate of soda and potassium cyanide, and heated on charcoal before the reducing flame of the blowpipe, gives bright red metallic particles of copper. These particles will dissolve in nitric acid; and if ammonia be added, in excess, to the solution thus formed, it gives a deep blue colour. If ammonia be added carefully to a copper solution, a greenish blue precipitate is formed; on adding a little more ammonia, the precipitate is dissolved and forms a beautiful azure blue solution; and this is a delicate test for copper. If a little hydrochloric acid be added to a solution until it is distinctly

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acid, and a clean and bright piece of iron dipped into the solution—a knife blade will do very well—the iron or knife blade will soon become coated with copper, if that metal is present.

13. *Tin.*—This metal is very malleable and ductile, yet it is of a crystalline nature, and if a piece of tin be bent backwards and forwards the rubbing of the crystals against each other can be very distinctly heard. It does not oxidize in the air except when heated to its boiling point. Water has no action upon it, and dilute acids very little; but strong hydrochloric acid, strong nitric acid, and also alkalies act on it. A little powdered tin compound, mixed with a little bicarbonate of soda and potassium cyanide, and heated on charcoal in the reducing flame of the blowpipe, gives small globules of white ductile tin, and forms a white incrustation on the charcoal. These globules can be dissolved in nitric acid, and if mercuric chloride be added to this liquid a white precipitate will be formed.

One of the most characteristic tests for tin in solution is to put a bit of granulated zinc and a piece of platinum into the liquid, these two metals being put in contact in the liquid, then if tin be present a precipitate of metallic tin will form on the zinc as a grey spongy mass.

14. *Gold.*—This metal is not affected by air or water, and with perhaps one exception, not by any single acid. But it is acted upon by chlorine, bromine, and by aqua regia, which is a solution formed by adding one part concentrated nitric acid to 3 or 4 parts hydrochloric acid, and gives off chlorine. Gold exhibits a great attraction for mercury, forming with that metal a white alloy or amalgam If a little of the powdered substance be mixed with sodium carbonate, and heated on charcoal before the reducing flame of blowpipe, it will, if gold be present, give malleable yellow gold beads. If these beads be dissolved in aqua

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regia, and the solution absorbed on filter paper, and then moistened with tin chloride solution (Stannous chloride), a purple yellow colour will be formed.

The following is Professor T. E. Thorpe's test for detecting gold when existing in minute quantities:—Five or ten grammes (say 80 to 150 grains weight) of the finely powdered mineral are shaken with alcoholic tincture of iodine; the insoluble matter is allowed to settle, a piece of Swedish filter paper is dipped into the solution, dried, and then incinerated. If the ash be purple in colour, gold is present. To confirm the presence of gold, treat the filter ash with a few drops of aqua regia, evaporate to dryness at a gentle heat, and dissolve the residue in water; then pour this solution into a glass beaker placed upon a sheet of white paper. Next prepare a separate solution by adding ferric chloride to stannous chloride until a permanent yellow colour is produced. This solution is diluted with water, a glass rod is dipped into it, then into the gold solution, and a bluish-purple streak in the track of the rod confirms the presence of gold.

15. *Zinc.*—This metal is of a bluish tint of colour, highly crystalline, somewhat brittle when cold, but malleable when hot. It oxidizes superficially in air; decomposes water slowly at the boiling temperature, and rapidly at a red heat; and it dissolves in most acids. A little of the powdered compound is mixed with sodium carbonate, and heated on charcoal in the reducing flame of the blowpipe; if zinc is present a white incrustation is formed on the charcoal, and the metal volatilizes and colours the flame to a bluish-green. The incrustation is *yellow* when hot, *white* when cold; and if a little cobalt nitrate be added to it, and it be again strongly heated in the outer flame, it assumes a *fine green colour.*

Ammonium sulphide added to a solution containing zinc

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gives a white precipitate, and it forms better if ammonia is also added. The precipitate is readily decomposed by dilute hydrochloric and sulphuric acids, with evolution of sulphuretted hydrogen, also by nitric acid, but it is insoluble in acetic acid.

16. *Barium.*—This metal occurs chiefly as a sulphate, and as carbonate. Barium compounds, when held in the fusing zone of a Bunsen flame, or when heated on thin platinum wire in the inner blowpipe flame, give a yellowish-green colour to the outer flame, especially if moistened with strong hydrochloric acid.

Potassium chromate gives a bright lemon-yellow precipitate, even from very dilute barium solutions, providing they are neutral and only slightly acid. The precipitate is soluble in nitric, hydrochloric, or chromic acid; but is re-precipitated by ammonia.

Sulphuric acid, added to a barium solution, gives a heavy white precipitate, especially if a little hydrochloric acid be added and the solution boiled.

17. *Nitric acid: nitrates in solution.*—Put a small portion of the solution to be tested into a small test tube, add *very cautiously* an equal volume of *pure* sulphuric acid, allow to cool, and if a precipitate is formed allow that to settle, then add gradually a little ferrous sulphate solution; and if nitric acid be present, a violet, red, or dark brown ring will be formed at the point of contact of the solutions. If the solution to be tested does not give a precipitate with sulphuric acid, then this test can be well made by first adding the ferrous sulphate to it, and then carefully pour a few drops of strong sulphuric acid down the side of the test tube, and the brown ring will be formed.

NOTE.—When water and sulphuric acid are mixed, a great amount of heat is generated; a mixture quickly made with equal quantities will raise the temperature to boiling point;

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therefore, to avoid accident, *never add water to sulphuric acid;* but always the acid to the water, and very slowly, causing the two liquids to mix gradually.

Mr. HALL: The point that struck me in the paper was the doubt cast upon the fact whether the heat of the earth increases at the rate of one degree in 60 feet. If that has not been established, the sooner it is established in the way suggested the better; because in calculating the available coal supply, the temperature underground is one of the things to be taken into consideration.

The CHAIRMAN: I think, in addition to taking the temperature of the strata, it would be just as well to take the temperature of the air in the working places.

Mr. STIRRUP: I believe it has been well ascertained that rocks under the same conditions of depth and pressure vary in their capability of transmitting heat. Many years ago a Committee was formed by the British Association for testing the thermal conductivity of rocks, and the variation in different rocks was something considerable. There is not a fixed limit of increase of underground temperature of 1° for every 60 feet; it varies, I think, from about 1° for every 51 to 60 feet. Of course there are many things to be taken into account in taking the temperature at different depths.

The CHAIRMAN: One degree for 60 feet has probably been determined as a correct average.

This concluded the business of the meeting.

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APR 10 1893

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XXII. SESSION 1892-93.

WIGAN MEETING.

THE ORDINARY MEETING of the Members was held on Friday, January 13th, 1893, in the Mining School, Wigan. The Vice-President, Mr. W. SAINT, H.M.I.M., in the Chair.

Additions to the Library, October to the end December, 1892 :—

Bradford: Twenty-second Annual Report of Free Libraries for 1892.

Cornwall, Camborne—Mining Association and Institute of Cornwall: Transactions, Parts 1 and 2, Vol. III.—*From the Institute.*

Dublin, The Royal Dublin Society: Second series, Scientific Transactions, Vols. IX., X., XI., XII., XIII., for year 1891; also, new series, Transactions, Parts 3 and 4, Vol. VII., 1892.—*From the Society.*

Edinburgh, Royal Society of: Proceedings, Vol. XVIII., 1891-92.—*From the Society.*

Essex Naturalist: Journal, Nos. 9-11, Vol. VI.—*From the Essex Field Club.*

Herefordshire Natural History Society and Field Club: Transactions, Parts 8 and 9, Vol. VI.; Part 2, Vol. VII.—*From the Society.*

Leeds, Yorkshire Naturalists' Union: Transactions, Part 17, for 1891.—*From the Society.*

—— Geological Association: Transactions for 1891-92.—*From the Association.*

London Geological Society: Quarterly Journal, No. 192, Vol. XLVIII.; also List of Members.—*From the Society.*

—— Geologists' Association: Proceedings, Parts 9 and 10, Vol. XII.; also List of Members for 1892.—*From the Association.*

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London Geological Magazine: Nos. 340-342, Vol. IX.—*Purchased.*

——— Iron and Steel Institute in America in 1890: Special Vol. of Proceedings.—*From the Institute.*

——— Palæontographical Society: Monographs for 1892.—*Purchased.*

——— Royal Society: Proceedings, Parts 314 and 315, Vol. LI.; Part 316, Vol. LII.—*From the Society.*

——— Iron and Coal Trades Review: Nos. 1285 and 1290, Vol. XLV.—*From the Editor.*

Manchester Geographical Society: Journal, Nos. 10-12, Vol. VII.—*From the Society.*

——— Literary and Philosophical Society: Memoirs and Proceedings, fourth series, No. 2, Vol. V.—*From the Society.*

Midland Institute of Mining and Mechanical Engineers: Part 114, Vol. XIII.—*From the Institute.*

Newcastle-upon-Tyne, North of England Institute of Mining and Mechanical Engineers: Transactions, Part 3, Vol. XXXIX.; Part 5, Vol. XL.; Part 5, Vol. XLI.; Annual General Meeting.—*From the Institute.*

Hamilton, Scotland, Mining Institute of: Transactions, Parts 4, 5, 6, Vol. XIV.—*From the Institute.*

Fossil Botany. By H. Graf zu Solms-Laubach.—*Purchased.*

Physics of the Earth's Crust. Second edition. By Osmond Fisher.—*Purchased.*

On the Causes of the Phenomena of Terrestrial Magnetism.—*Presented by the Author, Henry Wilde, Esq., F.R.S.*

Canada and U.S. America.

Canada, Ottawa, The Canadian Mining Review: Nos. 9-11, Vol. XI.—*From the Editor.*

U.S.A., Denver, Colorado Scientific Society: On the Post-Laramie of Middle Park (Col.), 1892; also a Volumetric Method for the Determination of Lead.—*From the Society.*

——— Indianopolis, Geological Survey of Indiana: Eighteenth Report, September, 1892.—*From the Survey.*

——— Minneapolis, Geological and Natural History Survey of Minnesota: Nineteenth Annual Report for 1890.—*From the Survey.*

——— Minneapolis, The American Geologist: Journal, No. 4; Vol. X.—*Purchased.*

——— New York, American Institute of Mining Engineers: Transactions, Vol. XX.—*From the Institute.*

——— Philadelphia, Franklin Institute: Journal, Nos. 802, 803, 804, Vol. CXXXIV.—*From the Institute.*

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U.S.A., Scranton, Pa., The Colliery Engineer: Journal, Nos. 3, 4, 5, Vol. XIII.—*From the Editor.*

——— Washington, United States Geological Survey: Mineral Resources of United States for 1889-90.—*From the Director of Survey.*

——— Wisconsin Academy: Transactions, &c., Vols. II.-VIII., from 1873 to 1891.—*From the Academy.*

INDIA.

Calcutta, Records of the Geological Survey of India: Part 3, Vol. XXV.—*From the Governor General of India in Council.*

AUSTRALIA.

Brisbane, Queensland Museum: Annual Report for 1892.—*Presented by the Trustees.*

Melbourne, Geological Society of Australasia: Transactions, Part 6, Vol. I.—*From the Society.*

Sydney, Geological Survey of New South Wales: Records, Part 1, Vol. III.; also Index to Vol. II.; and Palæontology, No. 5.—*From the Hon. the Minister of Mines.*

——— Australian Museum: Report of Trustees for 1891.

——— The Australian Mining Standard: Nos. 199 to 212, Vol. VIII.—*From the Editor.*

Wellington: Mining Industry Report of New Zealand for 1892.

FOREIGN.

Berlin, Gesellschaft für Erdkunde: Zeitschrift, Nos. 2 and 3, Vol. XXVII.; Verhandlungen, No. 6-8, Vol. XIX.—*From the Society.*

Dresden, Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis, 1891.—*From the Society.*

Halle A/s, Verein für Erdkunde: Mittheilungen, 1892.—*From the Society.*

Kazan, Russia, Society of Naturalists of the University of Kazan: Part 6, Vol. XXIII.; Parts 1-5, Vol. XXIV.; Proceedings, 1891-2.—*From the Society.*

Lausanne, Société Vaudoise des Sciences Naturalles: Bulletin, No. 108, Vol. XXVIII.—*From the Society.*

Lille, Société Géologique du Nord: Annales, 17, 18, and 19, for years 1889-90, 1890, 1891.—*From the Society.*

Mexico, Sociedad Cientifica: "Antonio Alzate" Memorias, Nos. 11-12, Tome V.; Nos. 1-2, Tome VI.; Sinopsis Mineralogica, by C. F. de Landero.—*From the Society.*

Paris: Subterranean Explorations, various Pamphlets, 1892, by M. E. A. Martel.—*From the Author.*

Pisa, Atti della Societa Toscana di Scienze Naturali: Processi Verbali, May to July, 1892, Vol. VIII.—*From the Society.*

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Roma, Atti della Reale Accademia dei Lincei: Rendiconti, Fasc. 4, 8-10, Vol. I.—*From the Academy.*

St. Petersburg, Académie Impériale des Sciences: Memoires, Nos. 9, 11-13, Vol. XXXVIII.—*From the Academy.*

——— Kaiserliche Mineralogische Gesellschaft: Verhandlungen, Vol. XXVIII., 1891.—*From the Society.*

The Hon. Secretary (Mr. STIRRUP) announced that the usual Social Gathering would be held on the 27th January, at the Owens College Museum, on which occasion Professor Boyd Dawkins had promised to give an Address on the Coalfields of New South Wales.

THE COLLECTION OF FOSSILS.

Mr. STIRRUP also called attention to the following circular (which had just been issued), with regard to the fossils of the Lancashire and adjoining Coalfields. He said all the members would be aware of the close connection and interest that the Society had in the geological collections now housed in the Manchester Museum at Owens College; and, although they had there probably one of the finest collections of Coal Measure Fossils in the provinces, yet, unfortunately, the source of many of the specimens was unknown, and therefore useless for the purpose for which they were striving after now—namely, a collection, as complete as possible, of the Fossil Plants and Animals of the Coal Measures of Lancashire and adjoining districts, which should be fully labelled with the scientific name, the horizon and locality where found—a collection arranged stratigraphically, and freely open for reference to all, whether engaged in practical mining or in any branch of palæontological study. The Committee looked especially to those members connected with collieries for assistance in a

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work which would be valuable to them as well as being of much scientific value. He did not wish them to understand that it was simply fossils that they wanted, but rather the information these fossils would impart, if judiciously collected, and if any of the members or friends had fossils which they prized very highly and desired to keep, all they wanted to know was, what they were, and where they came from, so that they could be included in the lists to be published in the Transactions, from time to time, as the materials came to hand. In the course of a few years they might thus be able to bring out a full tabulation of the fossils they had in Lancashire and the adjoining Coalfields—a list which he expected would be of great interest and value. He had already received a few letters from gentlemen approving of the idea and promising assistance.

(Copy of Circular).

MANCHESTER GEOLOGICAL SOCIETY.

36, George Street, Manchester,
January 9th, 1893.

THE FOSSILS OF THE LANCASHIRE AND ADJOINING COALFIELDS.

Sir,—As you may be aware, the Society has had in hand, for some little time past, the work of systematically collecting and tabulating the fossils of the Lancashire and adjoining Coalfields, and as it is desirable to push forward the undertaking, as vigorously as possible, a small Committee of the Members has been appointed by the Council to aid and foster the work.

The object in view is to ascertain the distribution in time and space, or in other words, the vertical and horizontal distribution of all the fossil organisms, plant and animal, which are to be found in the Coal Measures, to note their presence, relative frequency and abundance in certain beds, and to record any facts that may come to light with regard to their life-history.

The information thus gathered will, it is expected, be of great scientific value, and it is confidently hoped that it will be the means

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of determining and correlating the various seams in different parts of the Coalfield, whose position is doubtful, and which have been disturbed by faulting and other causes.

Similar work has long been accomplished in many of the Continental Coalfields, enabling Palæontologists to guide with success the researches of those exploring new or unknown ground.

An example of the value of fossil plants in deciding the horizon and relative age of a new Coalfield is furnished by the fossils from the boring at Dover, an account of which was given at the recent November meeting of the Society.

On these grounds, the Committee appeal to all interested in such work, and especially do they solicit the help and co-operation of Coal Owners and their Agents, who by encouraging their Managers to give their assistance, and by according them permission to collect and forward, from time to time, any specimens of the fossil plants, fishes and shells which may be found at the pits under their charge, may thus afford valuable aid.

The Committee will be glad to hear from you, as to what help you can give, and will be pleased to receive suggestions in furtherance of their object.

JAMES TONGE, F.G.S.,
WILLIAM SAINT, H.M.I.M.,
JAMES GRUNDY, H.M.I.M.,
GEORGE WILD,
D. H. F. MATHEWS, H..M.I.M.,
} *Committee.*

MARK STIRRUP, F.G.S., *Secretary.*

NOTES FOR GUIDANCE IN COLLECTING AND PACKING THE FOSSILS.

1.—As the knowledge of the exact horizon or position in the Measures is of the first importance, it is essential that to each specimen be affixed a label giving the bed whence extracted, or its position with regard to any well-known seam, name of coal pit or quarry, and the locality.

2.—On no account *varnish* plant specimens, and avoid all rubbing and scratching.

3.—In packing fossils for transit, wrap each separately in paper and pack with additional paper, straw, hay, or shavings in a strong box. *Never* use sawdust or similar material.

4.—All specimens to be sent to the Geological Society, 36, George Street, Manchester (care of the Hon. Sec., M. STIRRUP), and after examination

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those that are not asked to be returned will be sent in the Donor's name to the Geological Museum, Owens College.

It will be as well to advise the Secretary when any package is sent. The carriage may be paid or not, as convenient.

N.B.—The Committee will be glad to know of any small private collections of Coal Measure Fossils, whose localities are well authenticated, if the owner is willing that they should be named and tabulated in the lists that are being prepared.

NEW MEMBER.

Mr. Thomas Horrobin, of Darcy Lever Collieries, Bolton, was unanimously elected a Member of the Society.

THE SUBSTITUTION OF STEEL AND IRON FOR TIMBER IN MINES.

By Mr. Isaiah Johnson.

For more than twenty years it has fallen to my lot to have charge of underground workings, and during that time I have almost daily had to supervise the setting and taking out of timber. Whilst superintending those operations the thought has repeatedly occurred to my mind—could not something of a more durable character than timber be used, so as to do away with the necessity of having to re-timber the main roads about every twelve months.

After careful consideration I resolved to try the use of iron props and steel girders, and my first attempt was in a main road ten feet wide. I secured this road for a distance of 300 yards with iron props and steel girders, and covered with ⅜in. boiler plating, the girders being set about three

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feet apart. This was done six years ago, and up to now I have not had to take out or replace a single girder.

We have now altogether 1400 yards of main roads secured with steel and iron, and about 1200 yards of that length is set in roads which would soon destroy the best known timber for mining purposes, namely, larch, as even that class of timber would not last more than twelve months at the longest. During that time, even with the greatest possible care, there would very likely be breakdowns and sometimes heavy falls, causing a stoppage of work and loss to both workmen and employers. In addition to that, in bad ground there might be falls which would stop the work for two or three days, and this would, as we are all aware, cause considerable loss to all concerned.

I will now describe the process of fixing the steel girders and props. The girders we use for main roads are 10 feet long, 5in. × 4in. × $\frac{3}{8}$in., and the section of props is 5in. × 3in. × $\frac{3}{8}$in. The cost of one girder 10 feet long, and two steel props 6 feet long, and 30 square feet of $\frac{3}{8}$in. boiler plate, would be, per lineal or running yard, about £1 11s. per yard. For securing the same area with timber, the cost would be from 10s. to 12s. per yard. Evidently the first cost of steel and iron would be nearly three times that of ordinary timber, but then the life of the former would be at least six times that of the latter, and would at the same time save the labour of refixing, and the risks of falls and consequent stoppages during working hours. I say at least six times the life of timber, because I have already proved that; and yet, so far as I can see and judge, it may last another six years; for, speaking generally, the road alluded to is as good as when first done. Therefore as time goes on, the great cost of the first outlay is gradually and yearly being returned. I therefore claim for steel and iron

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the following advantages, viz. :—First. That its life is at least six times that of timber. Second. That there is proportionately less risk. Third. No stoppages through falls. Fourth. That when a road is done with, the materials can be again used, or, even if they had to be sold, they would at least take scrap price, whereas timber when broken would be worthless. Therefore, taking into consideration the cost of labour, and the danger of taking out old timber and refixing new, which is very costly, apart from risk, I am convinced that the use of steel and iron for the securing of main roads is preferable to timber.

Mr. Burrows moved a vote of thanks to Mr. Johnson for his interesting paper. He thought Mr. Johnson had been very fortunate in his experience with iron. They began twenty years ago using common railway metals, and got very good results. He had seen them bend almost half a circle, but the rails they latterly bought were very brittle, and they broke like carrots when any weight came on them. They turned to girders, but changed them oftener than six years. They had set them on wood, and found that eased the weight, and they lasted a little better. At the same time they had girders on the surface which were twisted all ways, and the flanges had split; but he agreed that on the whole they were in advance of timber for heavy work.

Mr. Gerrard seconded the motion, and said he thought the success or failure of iron depended upon the conditions, and if Mr. Johnson would give them a sketch of the road, with regard to the workings, so that they might see what were the conditions in which iron had stood for six years, it would help them. He said there was

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an increasing feeling in favour of the use of iron if the conditions were favourable. He had seen some very striking cases where iron had answered admirably, and others where it had utterly failed. Not only where it answered was there an absence of repair of the roadways, less changes of timber and greater security, but he thought as the coal trade was so intimately associated with the iron trade if they could give the latter a lift it would be a distinct advantage to the coal trade.

The motion was passed, and a discussion on the paper followed.

Mr. I. Johnson, in reply to a question, said the road he spoke of had been standing for some years. In the yard mine there had been no weighting, but they had other roads where there had been weighting, though they had not been standing the same length of time.

Mr. W. Johnson said he had had to do for some eight or nine years with steel girders in mines, and from the start they found them very satisfactory. They had done a great deal better than any timber they had before. He considered that the value of a steel or iron girder in a mine as a bar was influenced by the nature of the mine in which it was placed. He did not think that in a matter of that sort plans of the place in which the bars would be placed would be of any value to the institution. As practical men they had to judge by the local circumstances, and he should not like them to come to a general conclusion from any premises that were not properly substantiated.

Mr. McGeever said they were using iron girders, and at one of the pits with which he was connected they put up a very large arch, but in consequence of the warrant lifting and side pressure, the spring of the arch had broken. His

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own opinion was that if the roads were lifting he should prefer timber girders till everything was set, and when all was set he should use iron girders, with two-feet square chocks instead of props.

The CHAIRMAN said, from the figures given by Mr. I. Johnson, there was a saving of about 50 per cent. for a period of six years, by the use of steel girders instead of timber, but he had not given any estimate of the saving of labour. He would like to know if any member had experience of the setting of steel girders in mines where the roof was not stable and where they had to be re-fixed repeatedly owing to side pressure, &c., so that they might get a comparison as to the applicability of iron or steel girders to mines having roofs of varying character.

Mr. I. JOHNSON said he had had some experience in that direction, and he thought steel was preferable to timber whether there was weighting or not, because timber once done was for ever done, but steel when twisted could be brought back to what it was before.

Mr. MORRIS said if they could keep the ends loose there would not be much broken timber. His experience was that it was cheaper to fill the roads and then re-empty them than it was to re-bar.

Mr. BOOLE said there was a good deal in what Mr. Morris said, but they were not always in a position to fill their roads or open them out when they liked. He had tried steel bars for a considerable time and found there was great economy in the use of them as against timber, even where the ground is not settled.

Mr. H. HALL said he had watched the introduction of iron girders in place of timber not always with satisfaction. He agreed very much with the conclusions Mr. Mc. Geever

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had come to. He thought that iron was excellent where there was no moving weight, but where there was a moving weight they would find they could overcome difficulties much better with timber. So far as he had seen girders on the top of timber props he thought the result was most unsatisfactory, and he agreed with Mr. McGeever that if they had a road that was specially difficult to manage they would have to fall back on timber. He thought with regard to timber and iron that some of the difficulties arose through not watching the ends, and easing them when the crush came on.

The CHAIRMAN said the iron girders when bent and under pressure were liable to fly out during repairs, and there was a danger of the men being hurt by them if they were not on the alert.

The discussion was then adjourned to the next meeting.

A PATENT MINER'S SAFETY LAMP, LIGHTED BY ELECTRICITY.

Mr. PRESTWICH, of the Protector Lamp and Lighting Company, Eccles, exhibited his Patent Miner's Safety Lamp, lighted by electricity. A number of lamps were exhibited, namely, the ordinary Clanny, Marsaut, Museler, and Thomas Thomas types, and the patentee claimed that he could adopt the principle to any existing type of lamps. The arrangement inside the lamp consists of two small terminals being attached to the extinguishing plate, in which is fixed a loop of platinum wire which slightly overhangs the wick. A brass pin insulated through the

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bottom comes in contact with the battery, striking the insulated plate. The platinum wire becomes heated to incandescence with the electric current and ignites the wick. The current in the storage batteries is kept up by a full equipment of fittings, in the shape of a small engine, dynamo, a cabinet containing all necessary arrangements such as ammeters, cut-offs, regulators, and storage batteries for the lamp room, small accumulators with safety tops being charged up from the dynamo and sent to different stations down the pit for re-lighting in case a man by accident or otherwise should lose his light. The advantages claimed were :—That the lamps can be cleaned and locked up ready for use, and need not be lighted until required, thus saving oil. The arrangement can be adopted to any existing type of lamps. The lamps can be relighted in any districts in the pit with safety, thus saving time and expense, should a man by accident or otherwise lose his light. That neither master or man can expose the flame after the lamp is put together for the day; and that all the lamps can be trimmed, &c., for the day, and no night shifts required, thus saving a great cost in the lamp-room.

MIS-SHOTS IN MINES.

By Mr. Henry Hall, H.M.I.M.

Mr. H. Hall said they all knew what a mis-shot was, and they were all aware that after having had a mis-shot they were bound to deal with it in some way. What they did not know was how to deal with it with comparative safety. He brought that matter before them with the object of gaining some information. The position seemed to be this: Let them assume for a moment that they had had a mis-shot

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in a narrow place; then the first thing that a man would do would be to fasten a piece of string or wire to the wires of the missed shot and tie it to a prop; he would then proceed to drill another hole, and try to blow out the original shot. On going to examine the coal he might find that the first charge had not been blown out, and that the mis-shot was still left in the solid coal. The question then arose: What was he to do next? Had he to drill another hole?—that was a second or rather a third hole, and try to blow out the charge, or was he to get a pick and try so to manœuvre as to recover the charge without exploding it. As a matter of practice, when a man went back and found that his mis-shot was still in the solid coal, he was not likely to think of going to the trouble of drilling another hole, and he proceeded to recover it with his pick, which was attended with the utmost danger. He was assuming that the charge was composed of some high explosive to be fired by a detonator, and he should like to know at what temperature the detonator would explode. That the dangers of recovering missed shots were very serious had been shown by the number of accidents that had happened recently. He had got several reports of accidents, which he thought could not be used for a better purpose than to enable them to come to some satisfactory conclusion as to what ought to be done in the matter, and he would read a few of the accidents, without mentioning names, which had occurred within the last twelve months. Mr. Hall then read a number of accidents, giving the causes and extent of the injury, and proceeded to say that, judging from the number of accidents, he thought it was quite clear that something ought to be done. The danger seemed to arise from the very low temperature at which the detonators would explode. They could not expect a collier to be very careful, and he got impatient with a shot when it missed fire, and there was no saying what he did to get it out. He hoped

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those present would be able to assist the inspectors in that matter. The only conclusions he had been able to come to up to that time were that they should make a rule that no person except the shotlighter or fireman should take any part in the recovery of a mis-shot, and then that even he should not adopt the plan of "picking" out a charge. When they talked about "picking" out, it did not mean unramming quite, although it approached it. There was no rule in the Act of Parliament that was better known to the colliers than the rule about not being allowed to unram a shot, and he did not think there was any rule that a collier thought less about breaking. He believed it was broken every day, both in Wales and Lancashire. The men constantly unrammed their shots, and the sooner the power was taken out of their hands the better. He should be glad to have any information possible.

Mr. Burrows said they were much obliged to Mr. Hall for his interesting paper, and he must say that the question he had propounded was very puzzling. There was one advantage in firing shots at night, and that was that it did away with a great deal of the impatience of colliers, as the shotlighter was responsible for the charge, and the collier had nothing to do with it. He had often thought it would be a serious thing if a shot were sent away in some coal and put on to a fire.

Mr. I. Johnson said at his colliery, if a shot missed fire, no one was allowed to go or interfere with it except the man in charge of the detonator.

Mr. Gerrard inquired what was the power of a detonator, say as compared with gunpowder, and also the number of accidents that had occurred during the past twelve months.

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Mr. HALL said eleven accidents had been reported to him.

Mr. GERRARD said that was proof of the importance of the question. Many of the accidents appear to have been brought about in unramming after missed shots. Official supervision with strict discipline ought to prevent shots being drilled out. It may be well to consider whether the use of the pick, or any tool to unram the charge, should be forbidden. In his opinion the direct use of any tool to expose the charge is unramming and contrary to the law. He quite agreed with Mr. Hall that the recovery of the unexploded detonators ought to be in the hands of a responsible official. In Lancashire the interval between a shot missing fire and re-entry is one hour. If this interval were increased, in many cases the recovery of the unexploded detonator could be done by a responsible official. He had known a case in which an electric detonator had hung fire, and there was danger from that cause.

Mr. DOBB said they fired some 16,000 shots at the colliery during the last year, and 23 had missed. The way they recovered these detonators was to bore a hole 9in. to 12in. from the old hole and charge it, then connect the wires of the mis-shot to the cable, so that when the mis-shot is fired, there is no difficulty in finding the mis-detonator. My instructions are strict on this point; the detonator must be found. When they are recovered they are brought to my office and I try to ascertain the cause of the mis-shot. In eight cases out of the 23 I have found it to be the fault of the detonator wires being broken, and in the remaining 15 I could not fire them with the battery. There are shotlighters appointed to deal with all shots, having to charge and fire them, no one else being allowed to interfere. All shots are fired between shifts, when only the firemen and shotlighters are down.

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The CHAIRMAN: With regard to what Mr. Gerrard says, if I understand him aright, he has given a case where a shot hung fire after an attempt had been made to fire it by the electric battery. If, as is usual in the North and East Lancashire district, the battery had been disconnected from the wires and then it had fired, we shall have to see about revising our rules, and the sooner the better, because a shot-firer may now go back to a mis-shot at once if he disconnects the battery from the cable and takes the battery with him.

Mr. BIGG-WITHER said the case mentioned by Mr. Gerrard of a shot hanging fire was the only one that had been reported from what might be considered a reliable source, but as the manufacturer of the electric fuze had assured him it could not possibly happen, and the experience had never yet been confirmed, it certainly was most improbable.

Mr. W. J. ORSMAN, of the Roburite Explosives Company, was asked to reply on the discussion, and in the course of his remarks he said: The temperature at which the contents of a detonator, namely, fulminate of mercury, decompose is about 300° centigrade. In the case of a missed shot exploding, it is not so much a question of temperature as of the detonator being struck by the iron pick of a collier. Fulminate of mercury is very sensitive to percussion, especially when struck by iron or steel bodies, and the simple pricking of the fulminate with a needle will cause it to explode. With an electric detonator the fulminate is completely surrounded by a copper capsule and the electric fittings. This is then placed in a cartridge, and tied in. In the case of a mis-shot, the usual practice is to bore another hole alongside, blow down the coal, and then find the unexploded cartridge. If proper care is exercised, this ought not to be a dangerous proceeding, as the detonator, being imbedded in the cartridge, would be quite safe, unless

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struck by a heavy blow by a pick or other instrument. It is probably necessary, further, that the detonator would have to be smashed and the fulminate loosened before explosion would take place. If a detonator is placed on an anvil and struck by a falling weight, generally the first blow only crushes it, and does not cause explosion. The fulminate being now exposed, will always explode with the second blow. The fact that whilst at some collieries where a large number of mis-shots have occurred, and no accident has ever taken place, whilst at others, accidents are frequent, seems to point out that proper care is not always exercised, and the suggestion of Mr. Hall, that only experienced men should attend at such cases, seems a feasible precaution in the right direction. In the case of roburite being the explosive used, no possible harm could result from the cartridge being struck a heavy blow, as this substance cannot be exploded by percussion. Further, the question has been raised as to the probable effect of a cartridge containing a detonator finding its way into a fire mixed up with or embedded in a lump of coal. If the cartridge consisted of any nitro-glycerine or nitro-cotton compound, such as dynamite, gelignite, carbonite or tonite, the result would be very disastrous. In the case of a nitrate of ammonia compound, such as roburite, experience has shown that no explosion of the latter takes place. Supposing a cartridge of roburite containing a detonator be thrown into a fierce fire, the nitrate of ammonia decomposes, at a temperature of 230° centigrade, this being below the detonating point of fulminate of mercury. Consequently not sufficient heat can get to the detonator until all the surrounding roburite has been burnt or fused away. The nitrate of ammonia in decomposing absorbs an enormous amount of heat, a large volume of steam is liberated, and this appears to form an efficient protection to the detonator.

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When the naked flame reaches the detonator itself, of course a slight explosion takes place of the fulminate, but not more damage is done than would be caused by the burning of an ordinary sportsman's cartridge as used in fowling pieces. The occurrence of missed shots can be largely prevented by the action of managers in insisting that the shotlighters should test the exploders and cables at least once a week, the exploders to be tested on a voltmeter to see if the proper number of volts are registered (at least 65 volts), and the cables tested to see that the wires are not damaged by being broken or short circuited in any way. It is advisable in choosing exploders that those having a large reserve of power should be selected. Instruments are now made registering 120 volts, and only weigh a few pounds.

A vote of thanks having been accorded to Mr. Hall, the meeting terminated.

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CORRECTION IN PART III.

Page 123, 5th line from bottom, delete the first "not." The sentence should read as follows: "If the water does show acid, it will *not* be likely to contain any carbonic acid or carbonates," &c.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XXII. SESSION 1892-93.

MEETING AT OWENS COLLEGE.

An EXTRA MEETING of the Society was held, at the invitation of the Council, in the Geological Museum and the Beyer Buildings, Owens College, on the evening of Friday, 27th January, 1893.

The Members assembled in the Geological Museum, which was opened for their inspection, and after partaking of light refreshments in the Refectory, they adjourned to the Natural History Lecture Theatre, to hear the promised address of Professor Boyd Dawkins.

Mr. JOSEPH DICKINSON, F.G.S.,
in the Chair.

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THE COALFIELDS OF NEW SOUTH WALES.

By Professor Boyd Dawkins, F.R.S.

(With Sketch Map and Sections.)

CONTENTS.

1. Introductory.
2. The area covered by the Coalfields.
3. The amount of available Coal.
4. The quality of the Coal.
5. The accessibility of the Coalfields.
6. The classification of the Coal-bearing Rocks.
   (a) The Carboniferous Beds.
   (b) The Permo-Carboniferous Beds.
   (c) The Triassic Beds.
7. The comparison with the British Carboniferous Rocks.

1. Introductory.

The coalfields of the great Australian continent, now being rapidly opened up by the energy of the English race, cannot fail to interest the Manchester Geological Society, whose special function it is to gather information relating to our great coal industry, not merely because they promise to become the great centres of manufacture in the Southern Hemisphere, but also because they present numerous points of resemblance and of contrast as compared with the coalfields of Great Britain. It was my good fortune, in 1875, to visit and examine some portions of the coalfield of New South Wales, and to obtain a collection of fossils, which are now in the Manchester Museum. Since that time the classification of the rocks of New South Wales, proposed by

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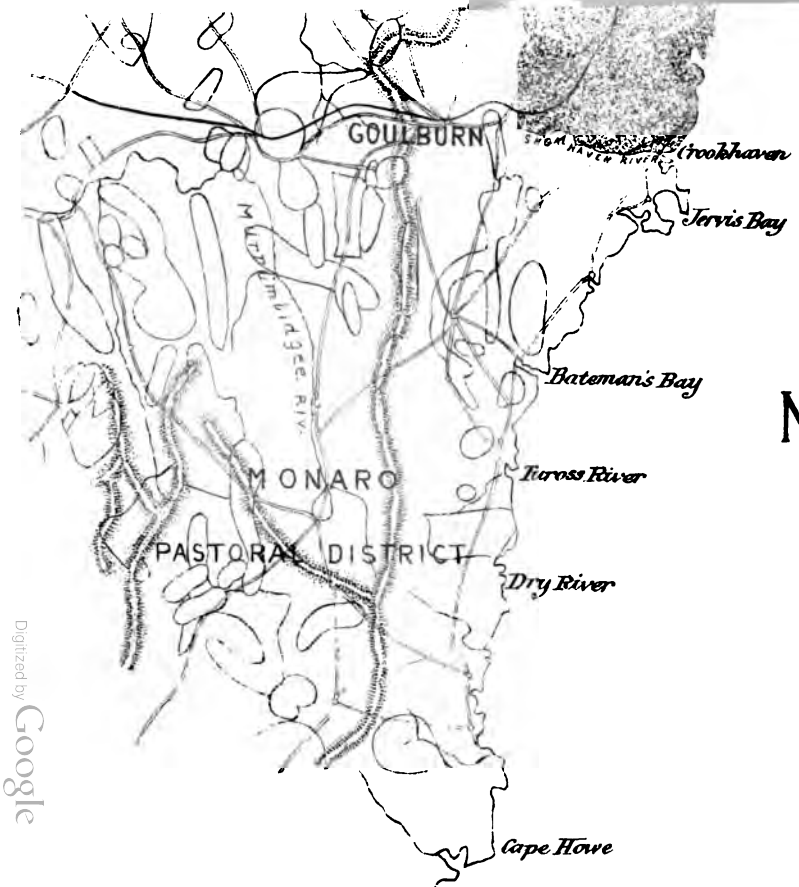

SKETCH MAP OF NEW SOUTH WALES

shewing the Localities of the

PRINCIPAL COAL FIELDS.

1893.

THE SHADED PARTS REPRESENT COALFIELDS.

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the late Rev. W. B. Clarke,* has been elaborated, and to some extent modified in details by the Geological Surveyors,† and more especially by Mr. C. R. Wilkinson and Professor Edgeworth David. The coals, too, have been critically examined by Professor Liversidge, the plants by Dr. Feistmantel, the invertebrates by Mr. Etheridge the younger, and the fishes by Mr. Smith Woodward. The following outline is based on the results of their work, together with certain observations of my own :—

2. The Area of the Coalfields.

The coalfields of New South Wales (see map) consist of the great tract of coal-bearing rocks extending 180 miles along the coast, from Crookhaven in the South, past Sydney and Newcastle, to Stroud, near Port Stephens, in the North, and ranging westwards to the Blue Mountain Range, with a mean east and west breadth of 88 miles. It covers an area between the Blue Mountains and the sea of about 18,000 square miles.‡ There are also other coalfields to the north in the regions of the Clarence and Richmond rivers, and to the north-west within the watershed of the Darling and its tributaries in the pastoral districts of Wellington, Bligh, Liverpool, and Gwydir, which remain to have their boundaries defined with accuracy. They are, however, geologically connected with the Great Field, according to David, between Port Stephens and the Talbragor river (see map), and sweep northwards under the newer strata to the Darling and the

* The Bibliography of the New South Wales Coalfield, down to 1890, will be found in Palæontology (Department of Mines) No. 3, 1890, 4to., pp. 11-36.

† See Department of Mines, Geological Survey, Memoirs Palæontology Nos. 1 to 7.—Records of the Geological Survey of New South Wales.—Annual Reports of the Department of Mines, New South Wales.—Australasian Association for the Advancement of Science, 1887-1890.

‡ By Computation, 18,216; by planimeter, 18,115 square miles.

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frontier of Queensland. Their total area is about 18,000 square miles. The re-appearance of the same Coal Measures in Central Queensland, from underneath the newer rocks, proves that these occur in the whole of this vast area. If these be left out of consideration, the great coalfield of New South Wales occupies an area which is considerably greater than that of the united coalfields of the whole of the British Isles. If they are counted, the united area amounts to a total of 36,000 square miles, or 70 per cent. of the total area of England.

3. The Amount of Available Coal.

The amount of available coal in seams over two and a half feet thick, and within 4000 feet of the surface in the fields of New South Wales, is estimated by Wilkinson* at 78,198 million tons, or about the same quantity as the coalfields of Great Britain within the same limits of depth, but including seams over two feet thick.† According to David's calculation it amounts to about 130 or 150 thousand million tons. These estimates are, of course, only approximate, but they show that there are vast supplies of coal in New South Wales available for the purposes of commerce, and amply sufficient for a supply for many centuries.

4. The Quality of the Coal.

The quality of the coal is variable, as in our own coalfields, being bituminous, splint, or steam coal, and coking or non-coking. Where the strata have been very much disturbed it is anthracitic, as is the case in South Wales and in South

* Trans. Australian Assoc., Melbourne, 1890, p. 463.

† Hull. Coalfields of Great Britain, 1881, p. 500.

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Ireland. According to Liversidge* the coals contain as a rule less sulphur and more ash than that of the British Isles. They are suitable for steam navigation, and indeed are now generally used by steamers, the difficulty as to combustion, which was originally felt, being removed by a modification of the furnace-bars, which were originally planned to burn the steam coal of South Wales. There are also local developments of the oil-producing mineral Torbanite, the so-called Kerosene shale, which is largely exported for the manufacture of gas. It is identical in its chemical constitution with the Torbane Hill, or Torbanite of Scotland, which it rivals in richness, yielding from 150 to 180 gallons of oil per ton.

5. The Accessibility of the Coalfield.

The coals, too, in the great New South Wales Coalfield are so placed as to be readily accessible and workable without deep mining as in this country. The seams crop out in the valleys and ravines, and very generally are worked by adits driven in from the out-crop. In the collieries near Newcastle, the trucks are run into the workings loaded from the working face and conveyed direct to the wharves, where they are emptied by steam cranes into the coal-boats, for Sydney, Melbourne, Adelaide, or for San Francisco.

The great coalfield of New South Wales, in the quantity, quality, and general accessibility of its coals, is in my opinion without a rival, and must ultimately make the colony the great manufacturing power in the Southern Hemisphere.

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* Liversidge, *Minerals of New South Wales*, 8vo., 1888, pp. 141-153.

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6. The Classification of the Coal-bearing Rocks.

The coal-bearing rocks of New South Wales are of enormous thickness, amounting according to Professor David to 25,150 feet, and consisting of three groups belonging (*a*) to the Carboniferous, (*b*) the Permo-Carboniferous, and (*c*) the Triassic division, each being marked off by a physical break and a marked difference in the Flora. This classification is founded on Professor Edgeworth David's paper on "The Correlation of the Coalfields of New South Wales," read before the Australian Association for the Advancement of Science, Melbourne Meeting, 1890.—*Transactions*, p. 459.

(*a*) The first of these (see Fig. I. *a*) consists of a series of massive sandstones and conglomerates, and thin subordinate beds 11,300 feet thick, and resting upon the Devonian water-worn and eroded sandstones and quartzites. They are characterised by the following plants:—

Lepidodendron Veltheimianum, Stern.
Cyclostigma Aushale, Feist (=Stigmaria).
Knorria.
Calamites.
Sphenophyllum.
Archæopteris.
Rhacopteris.

The first five in this list are familiar forms in the Coal Measures of the British Isles; the sixth, Archæopteris, is closely allied to the fern of the Upper Old Red Sandstone of Kiltorcan, in Ireland; and the last is a fern peculiar to Australia.

These strata, from the presence of Lepidodendron, are termed Lepidodendron Beds by Feistmantel, and Rhacopteris Beds by David, from the presence of the latter fern.

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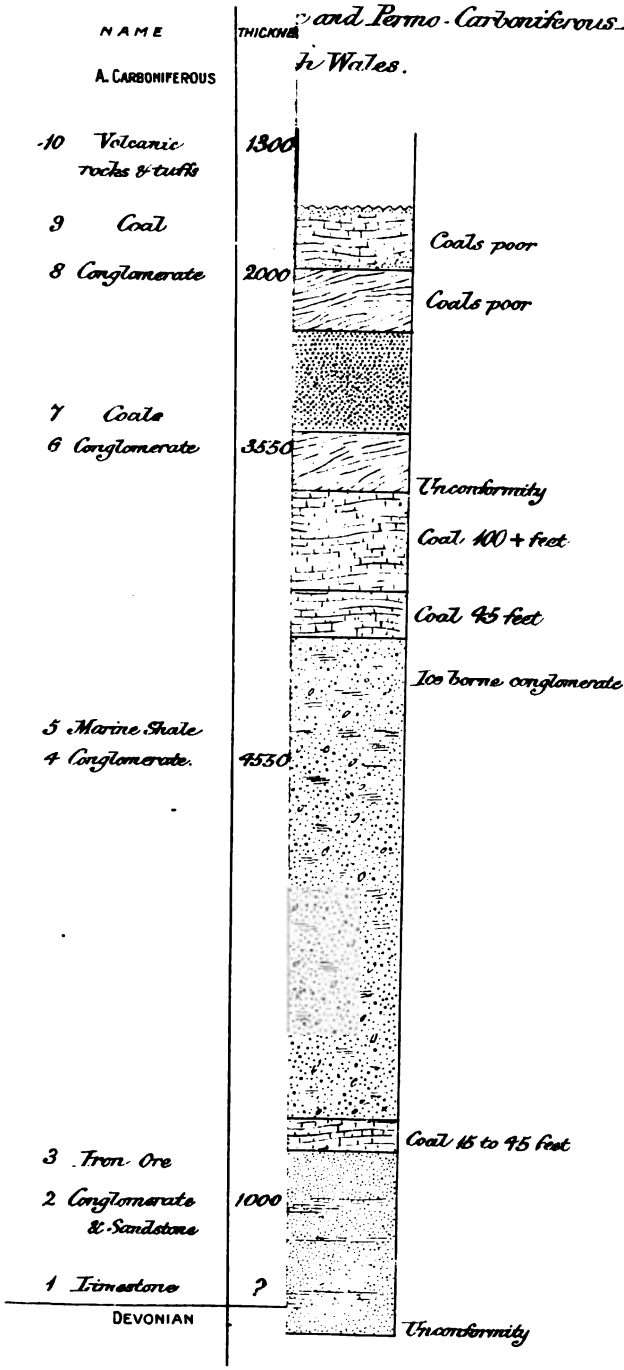
FIG I. Section of Coal-beds illustrate Prof. W. Boyd Dawkins' paper. T. Man. Geo. Soc. Part V. Vol. XXII.

of New South Wales. and Permo-Carboniferous Rocks



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The massive character of the sandstones may be gathered from the examination of Nos. 2, 4, 6, and 8, of Fig. 1. The beds which are subordinated to these are the Crinoidal Limestone at their base, No. 1; and a marine shale containing Conularia and Productus, No. 5. The marine beds also contain numerous well-known European carboniferous fossils such as Griffithides and Phillipsia among the trilobites, and Amplexus and Cyathophyllum among the corals. They are capped by volcanic rock (dolerite) No. 10, and tuffs 1,300 feet thick, which are not included in the total thickness of the rocks.

Bands of magnetic and titaniferous iron ore are also present, and the seams of coal are represented by seams of coal Nos. 7 and 9, which have a respective thickness of nine and seven feet. These coals are generally impure. In a seam, however, 10 feet thick, at Stroud, there are two feet of clean bright coal.

(*b*) *The Permo-Carboniferous Beds.*

The second group, containing thick and valuable seams of coal (see Fig. II.), is, like the first, of considerable thickness —no less than 11,150 feet. It consists of conglomerates, sandstones, shales, with groups of coal-seams at three distinct horizons, constituting the Greta series, No. 12; the Tomago, No. 14; and the Newcastle series, No. 16, with an aggregate thickness of about 200 feet of coal. In one section at Greta, described by Mr. Wilkinson, the upper seam is 31 feet, and 50 feet below is a lower one of 12 feet, which, in a space of two miles, increases to 22 feet 5 inches. Near Mittagong I saw two seams of coal cropping out of the side of the valley of the Nattai river, which, together with a layer of shale between them, are 25 feet thick. Layers, also, of Torbanite occur at two distinct horizons at Greta in

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No. 12, and in the Newcastle beds at No. 16. They are, however, variable in character, and occur in lenticular patches, like the cannel of Lancashire coal seams,—sometimes—as in the case of the layers from Mount Victoria (in the Museum collection), occupying the whole seam. At others, as, for example, in some parts of the workings at Hartley, they occupy only a part of the thickness, 3 or 4 inches of coal coming in at the top. At Piper's Flat, Wallerawang, I observed a thin layer, about 8 inches thick, in the middle of a seam, which gave the following section :—

	Ft.	in.
Sandstone rock.		
Splint coal	2	0
Torbanite	0	8
Dull coal	1	4

In another adit in the same seam the Torbanite was absent, and the whole 4 feet was occupied by coal.

The Flora which characterise this series of rocks contrasts strongly with that of the Carboniferous Group below, in the abundance of Glossopteris and of Vertebraria, the one a beautiful fern, and the other probably allied to the Equisetaceæ. Both occur in the Coal Measures of India, and are unknown in the Coal Measures of Europe and America. We are fortunate to possess a fine collection of both in our Museum.

The Marine-beds No. 11 and 13 contain fossils, some of which are distinctly carboniferous when looked at from the European or American standpoint, such as Archæocidaris and Phialocrinus, while others have, as Mr. Etheridge, the younger, observes with regard to Stenopora, Permian affinities!

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It may be noted that good iron ore occurs in association with some of the seams, as for example at Wallerang.

We must also remark that the glacial boulder deposit, described by Oldham and David, lies in the Upper Marine Series, No. 13 of Fig. II.

The conclusion that the upper portion of these beds represents the Permian is considerably strengthened by the fact that they are covered uncomformably by the Triassic Strata. It may further be remarked that they form one unbroken series, as in the case of the Permo-Carboniferous of Bohemia, where the Upper Carboniferous graduate into the Permian Strata, and are therefore grouped by the Australian geologists as one Permo-Carboniferous division.

(c) *The Triassic Beds.*

The third group of coal-bearing rocks consists of about 2,500 feet in thickness, which rest unconformably on the rocks below, and contains a characteristic fern, Thinnfeldia, and in its upper division Tœniopteris, which is a fern of distinctly secondary type. The Hawkesbury Sandstone in places, red, like our Bunter, contains also the remains of fishes, which are such as Belonorhynchus and Semionotus, which range in Europe from the Triassic age up to the Liassic age. The geological age, therefore, of the whole series is probably Triassic. No coals of importance have as yet been met with in New South Wales in these rocks.

7. Comparison with the British Carboniferous Rocks.

If these strata be compared with the Carboniferous Rocks in Great Britain, we find that they are about one-third thicker than our Lancashire and Derbyshire series, which may be taken as follows:—

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	Feet.
Coal Measures	7200
Millstone Grit	2000
Yoredale Shale	2000
Carboniferous Limestone..	5000
	16,200 feet.

There is the same Carboniferous Limestone in both.

The massive Carboniferous Sandstones of Fig. I. are paralleled by the equally massive Yoredale Grits and Shales of Pendle Hill, and by the Millstone Grits between Pendle and Burnley.

The Permo-Carboniferous Beds are probably the equivalents of our Lancashire Coal Measures, together with our feeble development of Permian rocks thrown in. It must be remembered that the Permians in Bohemia are coal-bearing, and also graduate into the Coal Measures of the carboniferous without any break, such as we have in Lancashire. The Triassic Beds in New South Wales have a tendency towards a peroxidated condition like the rocks of Lancashire and Cheshire.

When we consider the relative position of Britain and Australia on the face of the earth, the resemblance between the two coalfields strikes us with greater force than the contrast offered by the Floras. It is not a little strange that the Lepidodendroid element in the Carboniferous Forests should be found almost everywhere, and that the characteristic Carboniferous types of Europe should be equally widely spread. It points, in my opinion, to a uniformity of conditions of life, which is now not presented by the present surface of the earth, but such as might be expected from

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the earth being in those remote times hotter than it is now, and, therefore, less dependent upon the solar heat for its climate.

Mr. SAINT proposed, and Mr. WILD seconded, a vote of thanks to Professor Dawkins for his interesting and valuable paper.

The resolution was unanimously passed.

The CHAIRMAN invited discussion on the paper, observing that he had no doubt some gentleman present would have something to say, particularly with regard to that valuable mineral "Torbanite," which is now being imported into Liverpool for gas-making purposes.

Professor DAWKINS: I ought to mention, with regard to this, that I am not sure whether some of it is not being brought over in ballast. Indeed I know it is brought over as ballast, though it is an extremely light mineral, as well as for commercial purposes.

Mr. SAINT: I would like the Professor to indicate, if he will kindly do so, what is the usual inclination of the beds of coal found in New South Wales.

Professor DAWKINS: I think I can best answer that question by referring you to some of the sections. The seams which occur at Newcastle (N.S.W.) are very gently inclined—say something under one in 10.

Mr. SAINT: I think very great importance attaches to the existence of a bed of torbanite 4½ feet thick. I believe in Scotland they work it as low as 4½ inches, at a profit.

Mr. WATTS: I may say that I had the pleasure of listening to Mr. Wilkinson, when he came over to this

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country, at the meeting of the British Association at Leeds, when he described these coalfields so well put before us to-night by Professor Dawkins. Not only is New South Wales rich in coal, but Mr. Williamson told us that it was also rich in various kinds of minerals; and he looked forward to that country developing to such an extent that we English people must ultimately go there for various kinds of minerals that we shall require.

Mr. Stirrup: I think it must be gratifying to all Englishmen to think that we have in the Colonies of Australia a reserve of coal which will be available when—if it should so happen—our own supplies run short. The duration of the British coalfields has been a good deal discussed of late, and there is no doubt we have worked them very largely, at times wastefully, and have exported coal to other countries so lavishly, that in generations to come it may be thought we have acted very foolishly. However that may be, there can be no doubt our own coalfields are being exhausted rapidly, especially those beds which lie nearest the surface. In to-day's *London Standard* there appears a report by Herr Nasse, a German official mining expert, in which he gives an estimate—which of course is to be regarded only as an estimate—of the world's resources in the matter of coal and their probable duration. He certainly gives but a very limited period for the exhaustion of the European fields. Fortunately for us the English supply is not to be exhausted first, but he singles out Austro-Hungary, France and Belgium, and gives them five hundred years for the total exhaustion of their coalfields. Then, following rapidly, come those of the British islands, and last of course, Germany; so that in four or five centuries to come there will be only two great powers in Europe having supplies of coal at their command, and these under much more disadvantageous conditions than now.

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The statement, however, that we have heard to-night of the valuable fields that we have in Australia may probably be an inducement to our successors to emigrate—and our manufacturers to transfer their workshops to where cheap fuel may be had. It is certainly interesting to find that the New South Wales coalfield is such a valuable one, that it probably extends to the north into the adjoining Colony of Queensland, and may have other ramifications; moreover, there may be other regions on that great Continent not yet explored where similar deposits will be found. With regard to estimates of the world's coal supply, however, we cannot place much reliance upon them as large regions of the earth's surface remain as yet unexamined or unexplored. It is not very long since that I was reading the result of the French explorations in their new Colony of Tonquin. The Prince of Orleans, who has been recently travelling there, gives some extraordinary estimates of the extent of the coal-fields there. Some of those coal deposits are not, however, like those in England, so readily accessible or situated so near to the seaboard. Many of them, however, will be worked as the roads and railways get extended; and there can be no doubt that there is a large area of available coal not only in Tonquin, but also in Japan, in Russia, and other countries, and that, whatever Herr Nasse may say, the world's coal supply will last for many more centuries than he has estimated. Professor Dawkins has told us that there is a great future before New South Wales on account of its mineral riches. It is gratifying to know that the country belongs to the British Crown, and is colonized by Englishmen, our own kindred. We are much indebted to Professor Dawkins for the trouble he has taken to lay before us a large amount of valuable information, the result of his own personal observations, and of the labours of the Australian

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geologists. It is well known that in the early days of the colony when the Government were engaged in surveying some of these fields, a well-known palæontologist, Professor Mc.Coy, judging from the *glossopteris* and other familiar ferns which occurred in some of the beds, classified them as mesozoic, and also gave a very definite opinion to the Government at the time (1857) that these mesozoic coals of New South Wales would not be worth working. I dare say the very decided opinion he gave, kept many capitalists back from prosecuting further researches at that time. Since then, however, it has been found that these coals are very good bituminous coals suitable for all purposes, and that they are of the enormous extent Professor Dawkins has described.

Mr. Hick said: With your permission, I should like to add my quota of thanks to Professor Dawkins for his most interesting lecture. For myself, I have been most particularly listening to that part of it which dealt with the *Glossopteris flora* which occurs in Australia, and the exact location or position of which the Professor has so well described. It seems a curious thing that we should have this flora there and also, in similar formations, in South Africa and in India. Palæobotanists are apparently not quite satisfied as to the position which should be given to this flora. If it be truly carboniferous, then we have to admit that the uniformity of the carboniferous vegetation is not what it has been taken to be. That is to say, in different parts of the globe—supposing these beds are truly carboniferous—the flora has been quite as distinct as the floras in any two geographical provinces we have to-day. Another question which greatly interests me, and, perhaps, other geologists, though not of a very practical nature, is this: Seeing that this flora occurs over such a wide area—India, South Africa, and Australia—being practically

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identical in all those continents, has there not been some sort of connection between the different land areas? My question is a theoretical one, but of extreme interest.

Mr. JAMES NIELD said: I came this evening as a visitor, more particularly to see the Australian fossils, and to see what amount of identity there is, if any, between them and our own. I have been led to believe that the carboniferous flora of England and the Continent, and even of America and, to a large extent, of Australia also, are identical or nearly so. I am not surprised at that, seeing that the carboniferous rocks, although young, as it were, compared with those which were before them, yet belong to an immensely remote age. Comparatively, I say, they are young. The flora of that age had not had time to evolve any great amount of variation. Of course, there never has been a time in the history of the world when differentiation had made such vast changes and brought about such variation as at this present day. I am therefore, not surprised to find that there is a great amount of identity existing between the carboniferous flora of Australia and that of the other great continents.

The CHAIRMAN said: I have no doubt a large number of the members of the Manchester Geological Society have been expecting a paper of this sort for some time from Professor Dawkins. We remember well when he went out, now 18 years ago, and his coming back through America bringing some beautiful phosphates of lime which he laid before the Society. The Professor was very reticent about the object of his visit, which we have some knowledge of. It was to investigate those gas coals which I find now he, without much demur, calls "torbanite." It is now getting on for half a century ago since the Boghead coal was first discovered. It was first worked at Boghead, in Scotland, and

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after at Torbane Hill, and it was found in the lease taken by Mr. Russell, a banker, from a Mr. Gillespie. Mr. Russell, who was a most persevering man, worked this coal for some years, and endeavoured to get the gas companies to use it for gas making, but it was so rich it choked up all their retorts, and so disheartened was Mr. Russell at the difficulties he encountered in selling the mineral that he gave notice to terminate his lease. Negotiations went on, and amongst other letters that passed was one from Mr. Gillespie saying that this valuable gas coal was in itself sufficient to justify the holding of the lease, and that (to use a Scotch legal phrase) "the subject had not failed," and the lease must be continued. Well, during the working of it Mr. Russell, as lessor, had in his books described it as "gas coal." In 1853 a most important action was tried in the Scotch courts, the question at issue being whether this substance was coal or was not coal, and whether or not it was included in the lease. Mr. Gillespie contended it was not coal, and was not so included. The action was a lengthy and important one, Mr. Russell's witnesses alone would number fully 50 or 60, of whom I was one. There were amongst them microscopists, and there were miners, there were geologists, and there was, I think, almost every scientific branch represented. An amusing incident connected with it occurs to me. Three hotels were filled with these witnesses. One night, at table, an old gentleman rose and said: "Mr. Russell, I do not remember a time when I enjoyed myself so much as I have on this occasion. I hope I shall have the pleasure of meeting you in Edinburgh again next year."—(Laughter.) Mr. Russell thanked him, but hoped some one else would be the defendant.—(Laughter.) Well the case went on, and amongst other evidence was in fact that Mr. Gillespie's own bookkeeper had entered in his books the description "gas coal," and upon this and other points the verdict of the jury

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was that practically it was included in the lease. I do not say that they distinctly pronounced it to be coal, but that it was included in the coal lease. So it continued to be worked. The oil industry had then commenced; and one of our late members, Mr. Binney, was in partnership, holding a quarter share with Mr. Young, and they made a very large sum of money out of the manufacture of paraffin oil from this coal. They kept pretty much a secret how many gallons they got to the ton. Amongst other things which may be useful to mention in a practical society like ours, where there are so many mining men, the great tests for proving the richness of coal like this, were first the lightness of its specific gravity, secondly the giving of a brown streak, thirdly, the way in which a splinter of it would burn if lighted at a candle, and its great want of conducting power for heat, and from its aroma you could tell it was a good rich gas coal or torbanite (as Professor Dawkins now calls it). The litigation was still carried on. It did not terminate altogether with the jury case in Edinburgh. The last action I heard of was as to the portion of coal which was reserved. They were not to work within 100 yards of the mansion. That was perfectly clear, but litigation arose as to the point from which this 100 yards was to be measured. Was it to be from the outer wall of the house or from the foundation? I think the law decided that it was to be from the foundation. So valuable was the mineral that it was worth while sustaining an action at law for so small a quantity as that. It sold for £4 a ton at the latter end of the time. Going back about 50 years there was what was called "rum" coal, in Scotland—a bituminous shale. That was worked but to a small extent in those times, but now the quantity of that kind of coal, which is worked

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under the name of oil shale, is over two million tons a year.

Professor DAWKINS said: I am very much obliged to you for the way in which you have received this somewhat feeble outline of the great coalfield of New South Wales. I should like to be as brief as possible; and in the first place I will just answer a question put to me with regard to the occurrence of ironstone. Ironstone does occur in a great many places in association with these coals, and in one place I remember particularly there are valuable beds of clay ironstone. With regard to the precise position of the *glossopteris flora* I am hardly able to add much to what I have already said. Dr. Feistmantel, whose work I have placed upon the table, takes the view that I placed before you, that the *glossopteris*, in the whole of the Australian coalfields, marks the Permo-Carboniferous group of rocks; and he draws a distinct hard and fast line, as all the other people employed on the Geological Survey have done between these beds of *glossopteris* below and the beds of *temopteris*, and other plants, which belong distinctly to the Triassic Group. The question as to the amount of this torbanite in New South Wales is one which I should not like to attempt to answer. I would merely say that in one particular place—that is in the district of Mount Victoria, I traced it for sixteen miles, in the direction of Bathurst. With regard to the identity of our Carboniferous flora with the flora of Australia, it is certainly very extraordinary that we should meet with the same forms in the Carboniferous beds of a country so far away as Australia, and I can only explain it in the way suggested by one of the speakers that in all probability during the time this Carboniferous lepidodendron flora was flourishing—flourishing, I may say, in regions within the Arctic circle as well

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as over the whole area of the Americas—the conditions of life generally were more uniform on the surface of the earth than they are at the present time. But we must remember this—that the principal wealth of the New South Wales coalfields is derived not from the lepidodendron forests at all, but from the vegetation which is characterised by that singularly fine type of fern the Glossopteris, and defined too by the remarkable Vertebraria. There were also other Carboniferous trees represented by obscure fruits about which I could not venture to say anything at all. I might just mention that if any of you who care to look at a microscopic slide or two of this torbanite, I shall have great pleasure in showing it to you upstairs; and I hope on some future occasion to bring before the Society in some little detail the physical and microscopical structure of this singular mineral. There is no practical difference whatever between the torbanite of New South Wales and that of Scotland, so far as physical characters and oil production go. Under the microscope, however, I do find certain minute and unimportant differences.

The CHAIRMAN: We shall have this paper printed in the Transactions, and perhaps when it is in the hands of members there may be an opportunity of discussing it at greater length.

Mr. ELI SOWERBUTTS, on behalf of some of the visitors present, wished to say with what interest they had listened to the address of Professor Dawkins. He thought, looking at the scientific work that was being done, particularly under the auspices of the Queensland Government, they ought to be very proud that the men engaged upon that work were Englishmen. He alluded more particularly to

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the magnificent work of Mr. Clement Wragge, a young Scotchman, formerly connected with the Ben Nevis Observatory, and now Meteorologist to the Queensland Government.

(After the conclusion of the meeting the members had the opportunity of examining prepared sections of the torbanite, &c., under microscopes in the Laboratory.)

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XXII. SESSION 1892-93.

The ORDINARY MEETING of the Members was held on Tuesday, February 14th, 1893, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

The Vice-President: Mr. WILLIAM SAINT, H.M.I.M., in the Chair.

NEW MEMBERS.

The following gentlemen having been duly nominated were balloted for, and unanimously elected Ordinary Members of the Society:—

HENRY SMITH, 7, Sefton Street, Southport.

JOHN BROWN, Ringley Fold, Stoneclough, near Manchester.

JOHN THOMAS FAIRHURST, Penfall Colliery, Haydock, near St. Helens.

WILLIAM A. HEYES, Electrician, 5, Dawson Street, Bolton.

ARTHUR ROSS, Agecroft Colliery, Pendlebury, Manchester.

JOHN HOUSE, Rosebridge and Douglas Bank Collieries, Wigan.

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The Honorary Secretary (Mr. STIRRUP) called attention to several books which had been added to the Library, including Mr. H. Wilde's work on the Phenomena of Terrestrial Magnetism, a Monograph on the Anthrocosia of the Permian formation of Russia, by Professor Amalitzky, presented by the respective authors; also the new volume of the Annals of British Geology, by Professor Blake. The latter, Mr. Stirrup said, gave a record of the papers published by the principal Geological Societies of Great Britain during the year 1891, including that of the Manchester Geological Society.

A PROPOSED "MASKELL PEACE" MEMORIAL.

Mr. DICKINSON wished, before the regular business was proceeded with, to be allowed to mention that the Coal Association had determined upon endowing to the memory of our recently deceased President a "Maskell Peace" Mining Scholarship. An announcement to this effect had already appeared in some newspapers, including the *Times* and the *Colliery Guardian*. The Association had given £500, and it was thought that other friends of the late Mr. Peace would also be willing to subscribe, in order that a very fine Scholarship might be endowed.

MAP OF RIVER BASINS.

Mr. DE RANCE, referring to a map which he exhibited, said: I would like to draw the attention of the members to this map, which I have great pleasure in presenting to the Society. It more or less directly bears on geology. It is a map that I was instructed by Mr. Brunner, M.P., to prepare for presentation by him to the County Councils in reference to the carrying out of certain clauses in the Local

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Government Act of 1888, which gives power to Councils to act jointly, for the prevention of river pollution. The map is lithographed in three colours. All that is red in it represents water partings—partings betwixt river basins; all that is blue shows the rivers, or the names of rivers, and their tributaries; whilst all that is black in it is political—the divisions of the County Council districts, and so forth—and the names attached to towns are in all cases the names of county boroughs. No town is marked on the map except it is a county borough, and the circle to such borough is indicative of the population up to 200,000. Above that figure the circle would become so large that I have adopted a series of concentric circles. For instance, we have five circles for Manchester, indicating 500,000 inhabitants; two for Bristol, indicating 200,000, and so on. The map shows where counties overlap into river basins other than those which form the larger portion of their area; the map shows at a glance, how counties would be grouped and which county would send one or more representatives to form a joint committee for river business.

The CHAIRMAN intimated that discussion was then open on Mr. De Rance's paper on "The Relation of Geology to the Population and Agriculture of England and Wales."

Mr. DE RANCE: Before the discussion is entered upon I wish to draw attention to certain appendices to the published paper, which were not read at the previous meeting. I will do so very briefly. In Appendix 2 I draw attention to what appears to me a very curious thing, namely, that in the census of 1881 and the census of 1891, when they are compared, you find the Registrar-General has not only taken, apparently, a census of the inhabitants, but also of the acres; and we arrive at this very remarkable fact that, comparing the two, England contains 70,328 acres and

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Wales 9,542 acres less than we supposed; so that actually we have lost nearly 80,000 acres in the ten years. I give a list of the countries which have altered in area. Several are somewhat less; but there are a great number of counties which had considerably more acreage in 1881 than in 1891, unfortunately for us; and it is a curious thing that 16 out of the 18 which have lost area are maritime counties. You would suppose, on the face of it, that these 79,870 acres had been lost by coast erosion, but though the Coast Erosion Committee of the British Association (which I got the Association to appoint some years ago) have found a waste in some districts of a yard per year, and in others even more, I do not think to this cause can be assigned the tremendous falling off to which I have referred. In previous censuses—1861, 1851, and others—the area has always been given in the same figures as in 1881; and what is still more curious, the 1881 figures, which are obviously erroneous, appear in the official journal of the new Board of Agriculture in the agricultural returns of Great Britain for 1891. Here we have the County of Bedford, for instance, with a total of 295,509 acres. Those are precisely the figures given in the 1881 census; they are not the figures in the census of 1891, which are 294,983; and so on, if we were to follow all the different counties; so that we arrive at the fact that in ten years, for some reason or other (they have got, I presume, a more accurate estimate), the area of the country has decreased. But the strange thing is that all these censuses of the Board of Agriculture, brought up to date, are actually calculated on figures which have been abandoned by the Registrar-General. The Registrar-General has somewhat anticipated me in regard to the increase of population in coal and other mining districts, but he does not say anything about the change in the area. In reading the Memorial Volume, published by

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APPENDIX VI.

AGRICULTURAL STATISTICS OF THE BOARD OF AGRICULTURE FOR 1891, ESTIMATED IN APPROXIMATE PERCENTAGES OF COUNTY AREAS, BY C. E. DE RANCE; AND IN PERCENTAGES OF THE CULTIVATED AREAS, BY THE BOARD OF AGRICULTURE.

Groups of Population.	Counties. 1891.	Acres.	Per Cent. of County Area.							Per Cent. of Cultivated Land.		
			Wheat.	Total Corn Crops.	Total Green Crops.	Rotation Grasses, Clover.	Permanent Pasture.	Fallow.	Waste.	Corn Crops.	Green Crops and Rotation Grasses.	Permanent Pasture.
A.	Middlesex	181,317	2·7	6·6	7·1	1·4	44·8	0·46	37·7	10·7	17·3	72·0
B.	Surrey	483,178	5·7	14·9	7·1	5·1	31·1	1·7	38·7	23·8	25·3	50·9
	Kent	1,004,984	6·6	19·4	1·7	0·5	36·9	0·9	24·4	25·7	25·4	48·9
	Durham	647,592	3·1	11·4	4·9	8·0	41·0	1·8	32·9	17·0	22·1	60·9
	West Riding, Yorks.	1,716,389	3·4	11·9	5·4	4·3	49·2	0·6	28·8	16·8	14·8	68·4
	Lancaster	1,207,926	1·7	8·6	4·5	6·1	49·2	0·1	31·1	12·6	16·0	71·4
	Chester	705,493	2·1	11·2	5·6	8·3	51·0	0·007	23·0	14·6	18·7	66·7
	Stafford	732,434	3·8	12·3	5·7	6·4	57·6	0·4	17·4	14·9	15·3	69·8
	Warwick	566,458	7·7	17·9	5·2	6·2	56·7	1·4	12·6	20·5	14·7	64·8
	Glamorgan	547,070	1·1	5·1	2·4	3·9	39·9	0·2	48·2	9·9	12·8	77·3
C.	East Riding, Yorks.	804,798	9·0	31·3	13·3	11·2	25·2	1·7	16·7	37·7	32·0	30·3
	Bedford	295,509	15·1	33·5	10·2	7·4	32·9	3·8	12·3	38·1	24·8	37·6
	Herts	391,141	14·5	34·1	9·4	10·5	29·4	3·4	13·0	39·1	27·0	33·8
	Essex	1,055,133	1·3	33·7	9·5	9·6	23·2	0·004	20·9	42·6	28·0	28·7
	Berks	450,132	9·0	27·0	11·0	9·0	34·0	1·6	16·4	32·0	26·7	41·3
	Hants	1,032,105	7·4	20·1	10·5	10·9	24·5	1·8	31·7	29·1	35·5	35·4
	Sussex	934,006	7·6	17·7	7·2	6·8	38·8	1·7	26·6	24·2	22·8	53·0
	Notts	526,176	9·2	24·3	9·4	10·7	39·0	2·3	14·0	28·3	26·3	45·4
	Derby	656,243	2·7	8·4	3·2	3·6	64·2	0·6	18·1	10·3	9·2	80·5
	Leicester	511,719	5·4	14·1	4·2	4·7	67·9	1·4	7·5	15·3	11·3	73·4
	Worcester	472,453	8·7	18·7	6·9	6·5	51·4	1·1	13·8	21·8	18·5	59·7
	Gloucester	804,977	7·5	16·6	6·6	11·1	45·8	1·1	19·3	20·4	23·1	56·5
	Monmouth	368,399	2·5	6·6	2·9	5·0	51·6	0·5	33·3	10·3	12·1	77·6
	Flint	169,162	3·6	15·1	4·8	9·2	45·8	0·04	24·1	20·1	20·2	59·7

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APPENDIX VI.—*Continued.*

Groups of Population.	Counties. 1891.	Acres.	Per Cent. of County Area.							Per Cent. of Cultivated Land.		
			Wheat.	Total Corn Crops.	Total Green Crops.	Rotation Grasses, Clover.	Permanent Pasture.	Fallow.	Waste.	Corn Crops.	Green Crops and Rotation Grasses.	Permanent Pasture.
D.	Norfolk	1,356,173	11·8	31·6	14·4	12·1	21·2	0·8	19·6	39·3	34·2	26·5
	Suffolk	949,825	12·9	37·7	11·6	10·1	19·0	2·9	18·2	46·2	30·5	23·3
	Cambridge	524,926	21·0	45·7	14·4	9·6	20·7	2·5	6·6	48·9	28·9	22·2
	Northampton	629,912	8·6	22·2	5·7	5·4	53·8	1·9	11·9	25·0	15·0	60·0
	Bucks	467,009	9·0	22·0	6·0	6·0	49·0	1·5	13·5	26·4	16·8	56·8
	Oxford	470,095	9·9	31·0	10·0	10·0	37·0	1·3	11·6	32·7	24·6	42·7
	Northumberland	1,290,312	1·0	8·0	4·0	7·1	36·6	0·5	43·8	14·3	20·6	65·1
	Somerset	1,049,815	4·0	10·0	5·2	5·2	61·7	0·4	18·1	12·1	13·4	74·5
	Devon	1,655,161	4·5	14·1	7·9	12·5	37·9	0·6	26·6	19·2	29·0	51·8
	Cornwall	869,878	3·4	14·3	5·8	22·0	26·1	0·6	30·9	20·7	41·5	37·8
E.	Lincoln	1,767,962	12·7	33·3	13·2	10·5	27·9	1·2	13·7	38·5	29·1	32·4
	Huntingdon	229,515	16·2	35·1	8·9	8·8	34·4	4·9	8·1	38·2	25·0	36·8
	Wilts	859,303	7·7	19·7	11·0	9·2	46·1	1·0	11·7	22·4	24·2	53·4
	Dorset	627,265	4·4	14·3	8·6	8·0	46·8	0·5	21·5	18·3	22·0	59·7
	North Riding, Yorks.	1,361,664	2·6	14·8	5·5	5·4	36·5	1·4	36·5	22·2	19·7	58·1
	Salop	841,167	5·6	16·7	6·9	8·3	53·4	0·5	13·8	19·5	18·5	62·0
	Anglesea	193,511	0·2	12·9	5·1	17·4	41·5	0·003	23·2	16·7	29·4	53·9
	Denbigh	392,005	1·9	13·0	3·6	9·4	45·5	0·2	30·2	19·5	18·5	62·0
	Cumberland	970,161	0·5	8·8	4·6	12·1	40·1	0·1	34·0	13·4	25·9	60·7
	Carnarvon	369,482	0·1	5·5	2·8	6·9	38·2	0·002	46·0	10·7	17·4	71·9
F.	Rutland	94,889	6·2	22·0	7·8	7·0	50·1	1·0	3·4	24·4	17·6	58·0
	Hereford	532,898	5·9	14·2	5·2	6·8	48·3	0·7	22·0	18·7	18·3	63·0
	Carmarthen	606,172	1·4	8·4	1·1	4·6	57·3	0·1	26·0	12·9	9·2	77·9
	Pembroke	393,682	0·8	12·7	3·3	11·1	64·0	0·2	18·5	15·7	18·0	66·3
G.	Westmoreland	500,906	0·007	3·5	1·9	3·2	49·1	0·012	42·1	6·2	9·1	84·7
	Merioneth	385,291	0·2	4·3	1·0	3·6	36·6	0·002	57·6	9·6	10·4	80·0
	Cardigan	443,387	1·3	12·1	3·0	9·8	38·2	0·2	36·7	19·1	20·5	60·4
H.	Montgomery	485,351	2·6	9·0	2·2	6·1	38·0	0·4	43·8	16·6	15·6	67·8
	Brecknock	460,158	1·0	5·3	1·6	4·0	33·1	0·3	56·4	11·9	13·4	74·7
	Radnor	276,552	1·4	7·1	2·6	4·9	45·7	·03	42·4	11·7	12·9	75·4

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the Sanitary Institute, of the late Dr. Farr, I find Dr. Farr speaks of a certain county surveyor somewhere in the South of England being required, in 1831, to make surveys of certain townships, and his figures were put into the census of that date; and, so far as I can judge, it is those townships added together which give the total area of the county, and apparently the same figures have been taken from that day to this—even by the existing Board of Agriculture. I give certain other appendices which combine various items which have been published, showing the relation of the price of consols to the price of wheat. These have a remarkable relation the one to the other; and the Appendix has brought some flattering reviews of trade journals on my paper for calling attention to the fact, from an agricultural point of view; though it does not affect the geology. I had adopted the percentages drawn up by my colleague, Mr. Topley, which were founded on the Board of Trade returns for 1869. My object was to show the direct relation of geology to agriculture, and for that object it did not matter what the year was; but, looking at it from an agricultural point of view, I find that between 1869 and the present time a very considerable change has taken place throughout the country, and I therefore have drawn up another appendix (No. 6); in that I have put the very latest information I could get, the returns of the Board of Agriculture for the year 1891. I find it will not alter my grouping at all, but what it will do is to show that the wheat and corn districts, of all descriptions, have very considerably lessened and permanent pasture has become much more universal, not only in districts where formerly it was very largely prevalent, but in other districts where it was comparatively slight. These are, I think, the main points which did not appear in the paper.

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Mr. Thomas Ward (of Northwich) said: I read Mr. De Rance's paper with a great amount of interest, and I was very much pleased indeed with it. It seemed to strike out rather a new line in geological inquiry. But what I wish most to call attention to is not the paper, but rather the discussion which took place after the paper had been read—a discussion initiated apparently by Mr. Stirrup—on the apparent connection between the nature of the soil and various diseases. That is a question which has been worked out, I think, as regards heart disease and other things; and various parts of the country have been located as having certain diseases in excess. Thus, the question seems to have arisen whether the salt districts of Cheshire, and Northwich in particular, enjoyed a freedom from zymotic disease. Professor Boyd Dawkins seemed to ask the question rather, I think, in a sceptical tone,—he having been very much in that district—and my friend, Mr. De Rance, seemed to have an idea that we were living in a kind of Paradise, where we were free from any zymotic disease. Well, unfortunately, that is not the case; nor do I know that the salt districts are freer from zymotic disease than other districts where there is no salt. Unfortunately for me, I happened for about eleven or twelve years—up to 1886—to be the Chairman of the Sanitary Committee of the Northwich Local Board, and am one of those gentlemen whom Mr. De Rance referred to as having been very busy in getting a fresh water supply for that district. The assertions made were certainly not correct, because the very thing which caused the looking for a fresh supply of water was really the prevalence of zymotic disease caused by drinking the water of the particular brook referred to. So serious was the state of matters at one time that a special Commissioner came from London to inquire; and, as a result, we were told to look out for a fresh water supply, as we could not be allowed to go

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on using the water from that brook any longer. Typhoid fever had been clearly traced to it. We know that of late years, since the appointment of medical officers of health—and Cheshire has one of the best in the kingdom (Dr. Fox, of Lymm)—the public health has very much improved. Dr. Fox, when appointed, began at once to deal with the insanitary condition of Northwich. During 1878 we had 68 cases of zymotic disease in the urban district—the Local Board district of Northwich. I think you will consider that, in a population of a little over 10,000, as it was then, rather a large percentage. It was between 6 and 7 per cent. of the death rate of the district in that particular year. The doctor took it into his head to grapple with this, and, I think, he has done so very successfully, for the zymotic diseases of the Northwich district now are much fewer, and the deaths arising from them are fewer, than they were before Dr. Fox was appointed. The Local Board has, of course, been engaged in sanitary operations and improving the water supply. Mr. De Rance seemed to think that there had been no zymotic diseases in Northwich proper; only in the Castle district. Well, that might have been so once, but, unfortunately, last week there were two cases in the Castle, and two deaths from typhoid last year. It has appeared in my own family in one case—that of my eldest daughter—with fatal results. A man at our works also died of the disease. These cases occurred in Witton, where Wadebrook water was used. Then, we have not been free from small-pox; and measles have been very prevalent at various times, requiring the schools to be closed; we have also had whooping cough. In fact, all the zymotic diseases have been prevalent at one time or another, and some of them, at times, almost epidemic. I thought, seeing the statements made before this Society, that it would hardly be a proper thing to let it go forth that we in Northwich were perfectly

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free from zymotic diseases, and that there was something in the nature of the salt itself, or of the soil, which caused us to be so free. I do not know that I need say more upon this subject. Dr. Fox has treated the matter most admirably in his annual reports, and I think he has in every one of them mentioned cases of zymotic disease. He started in 1878, when there were 68 deaths from zymotic disease; then, in 1879, there were 58; in 1880, 38; in 1881, 19; in 1882, 19; in 1883, 20; in 1884, 36; and now, whilst Dr. Fox's report last year was a more favourable one, still we have not succeeded in getting rid of zymotic disease, measles having being very prevalent, and in many cases fatal. The deaths from zymotic diseases, which in 1878 numbered 68, were in the last year—that is, 1891—only 15. But Dr. Fox remarks that typhoid fever has reappeared "this year worse than the year before." For great perseverance in sanitary matters, he gives credit to the Local Board in every report, and the water supply he considers is now one of the purest in the kingdom. Therefore, although Mr. De Rance thought we had been making a great change for the worse in going from the Wade Brook to Cote Brook springs, yet, from all I can see, and all I know about the matters, the change has been a very beneficial one. Having become accustomed to the better supply from Cote Brook, the Northwich people have decided not to take any more of the Castle water. If, unfortunately, we had had to depend upon the stream which was our source of supply for many years, we should have been without water, because that stream has been polluted by waste from a chemical works, which has been built upon its banks.

Mr. De Rance: Although this portion of the subject was not a part of my paper, I must plead guilty to having in the discussion made the remarks to which Mr. Ward takes exception. I am sorry to hear from him that zymotic

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diseases were in Northwich in days gone by. I certainly, unless my ears are very much mistaken, heard evidence given in the House of Commons which showed that, at all events at that time—I thought it was for altogether, but apparently it was only for the year in question—the only case of typhoid fever was in the district supplied by the Castle well, and that there was no disease in the district supplied from the stream by the Company. Nor was there any reason why there should be disease, cultivated land was only of limited area, and houses were very few and far between. The supply Mr. Ward has now got, from Cote Brook, is in a district where there is also some drainage from farm houses, and the water itself is derived from drift sands—in other words from the very bed where the water in the Castle well has its source, although a long way off. At the same time it is likely to be a far purer supply than the Castle well, because near the latter there is a very large farm, and there is great risk of the water getting contaminated from the highly-manured land. But my great objection to the Cote Brook water is that it is peaty, no doubt through the energy of the Northwich men by means of proper filtration, they have got rid of the peat; but I always felt regret that so large an expense was gone to with the result that they get a water not much better than that they had before.

Professor Boyd Dawkins: I have listened to what Mr. Ward has said with very great pleasure; and his comparison of the present sanitary condition of Northwich with its condition in previous years should be received with a considerable amount of satisfaction, because we all know that this present year is one of very considerable zymotic import to almost every part of the country. Zymotic diseases are increasing sporadically everywhere; therefore, to have such a good report as we have heard from Mr. Ward to-day, with

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regard to Northwich, is to my mind extremely satisfactory. I think, looking at the conditions of Northwich, that there is no reason to suppose that in past times there was any special difference between the health of that and any other place. We know that good health depends on two essentials—first a good water supply, and secondly getting rid of sewage. With regard to the former I do not know that, in the past, Northwich had a particularly excellent water supply; and as to sewage I believe it is a fact that the continued sinking of the town has caused a considerable disturbance of the ordinary gravitation of the drainage through the natural outlets.

Mr. Dickinson: I do not know whether Mr. Ward was one of the Committee which selected the site for the new cemetery at Northwich. It is on high ground, beautifully sandy, with scarcely any covering of clay. Is it not likely that the drainage from that cemetery, so situated, will affect the health of the people dwelling on the lower ground near it? If they had selected a site in the Weaver or the Dane Valley, on soil, it would have been much more healthy.

Mr. Ward: That question was discussed, and really according to the report of the medical officer of health the neighbourhood of the cemetery is the most healthy part of the town.

Mr. Stirrup: I am partly responsible for the turn the discussion took on Mr. De Rance's paper; but I am not at all sorry, seeing that it has been the means of bringing our old friend, Mr. Ward, amongst us once more. Unfortunately he has dissipated the view I had been led to hold that Northwich was really a kind of sanitary station, where one might go in search of health, its healthy condition being supposed to be due to the salt manufacture. It was a question I put on this point to Mr. Dickinson and Professor Dawkins that started the discussion which has brought

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Mr. Ward here. We are all sorry to hear that Northwich is no better than other places, and that possibly it is a little worse than some. However, as Mr. De Rance has said, all this is somewhat outside the purpose of his paper. I am very glad indeed, on behalf of the members, to accept this map which Mr. De Rance has been good enough to present to the Society. We all know that the population is leaving the agricultural districts and getting concentrated in the towns. Whether this is to continue we cannot tell; at any rate in years to come it will be valuable to have a record of the state of things now existing, as shown in the maps and statistics which Mr. De Rance has brought before us. Where coal is cheap, manufacturers will settle, and of necessity the population must follow. There was one remark, taken by Mr. De Rance from Mr. Topley's paper, to which perhaps exception might be taken, namely, that "agriculture depends on climate, and climate mainly on contour, and contour mainly on geological structure." That is so only in a broad and general sense; for it cannot be said that climate mainly depends on contour without some reservation. Many things affect climate—geographical position, length of the days and nights, and also whether a district is wooded or bare, ocean currents, &c.

Professor Boyd-Dawkins: The point referred to by Mr. Stirrup is one which occurred to me while Mr. De Rance was reading his paper. I do not think we can accept the statement that climate is dependent on contour except in the broadest and most general sense. As a matter of fact climate is not dependent on contour in such low altitudes as the greater part of the area of the British Islands. It is dependent on westerly winds, nearness to the Continent, and so on. The contours only affect climate in proportion to the extent of sandy or clay subsoil. A wet soil will give you a different climate to a dry soil; therefore, as Mr.

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Stirrup has observed, we must take that statement in the broadest and most general sense. I did not, however, rise to speak on that point: I thought it might interest the Society to know what went on in this country before there were any centres of population, in the modern sense, at all. It has been my opportunity to study the distribution of population in this country before any large cities came into existence; and the practical result has struck me in this way: that originally the principal population in this country (in the neolithic age of bronze and the pre-historic age of iron), was mainly centred on the higher grounds that were naturally well drained, and on which the soil was comparatively dry; and in consequence of that, whenever we have chalk downs and wolds there, we have evidence of a comparatively large population right down, say, to the beginning of history. That really holds good with regard to all the lower elevations in these islands. But as time went on, and as the forests—which, in the first instance covered pretty nearly every part, excepting some of the uplands—began to be cut down, apparently the conditions of the drainage were altered, and the river valleys, which now represent the most fertile parts of these islands, gradually became more and more drained and ultimately passed into such a condition, that farmers could work them. As that went on the population drifted down to the lower grounds; and, as far as I understand it, that drifting has practically been going on ever since. But of course the drift of population into the more accessible regions is a process which has been very largely increased by the development of great centres of commerce and manufacture in various parts of the country. I merely throw out this as a contribution to this interesting discussion. It seems to me of considerable interest because it shows that long before there were any of those centres of population which now exist the population of these islands

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was drifting downwards from the uplands to the lowlands; and we know that the process is going on at the present time.

Mr. De Rance, in replying upon the discussion, said: I hardly think, Mr. Chairman, that I have anything to reply to. I thank the members for the kind way in which they have received the paper. It appears to have excited interest, here and elsewhere. I have also to thank Professor Boyd Dawkins for his remarks, at the previous meeting at which he said I had broken fresh ground, but I cannot but feel that I then sailed under false colours, as Mr Topley had already broken up the ground, except that he did not apply this principle to the question of population. Professor Dawkins's remarks to-day as regards our earlier history are exceedingly interesting, as showing that geology, independently of mining centres, influenced the population in pre-historic times.

SECTION OF STRATA SUNK THROUGH IN No. 2 SHAFT, DEAF HILL COLLIERY, CO: DURHAM, for the Trimdon Coal Co. during the years 1891-92, by Mr. Frank Coulson, per Mr. Thomas Bell, H.M.I.M., with notes on the Fossil Fish of the Marl Slate therefrom by Dr. R. H. Traquair, F.R.S.

(Communicated by Mr. Mark Stirrup.)

No.		Fas.	ft.	ins.	Fas.	ft.	ins.
1.	Strong Clay and Gravel	9	0	0			
2.	Strong Clay and beds of Marl	2	3	2	11	3	2
3.	Marl and Limestone	12	1	2			
4.	Limestone and Marl beds	6	0	0			
5.	Strong Honey-combed Yellow Limestone	14	0	0			
6.	Honey-combed Limestone	7	2	9			
7.	Blue and Yellow Limestone	5	2	5	45	0	4
8.	Marl Slate (Fish Red)	0	4	5	0	4	5

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No.		Fas.	ft.	ins.	Fas.	ft.	ins.
9.	Blue Sand, *Lower New Red Sandstone*	0	1	9			
10.	Yellow Sand ,, ,, ...	0	4	8			
11.	Blue Sand ,, ,, ...	0	1	0			
					1	1	5
12.	Soft Blue Metal	0	3	6			
13.	Blue and Red Metal	4	0	7			
14.	Red and Grey Post	2	0	4			
15.	Red Sagre Clay	0	2	7			
16.	Strong Red and Grey Metal	3	1	0			
17.	Grey Metal, with black partings	1	0	11			
18.	Blue Metal, with balls of Ironstone	1	0	7			
19.	Grey Metal	1	1	0			
20.	Strong Grey Metal, with balls of Ironstone ..	0	4	6			
21.	Red and Grey Post	3	5	0			
22.	Ironstone Girdle	0	0	2			
23.	Red and Grey Post	2	1	10			
24.	Grey Metal	0	2	6			
25.	Coal, mixed with Black Stone ($\frac{3}{4}$ Seam)	0	3	5			
26.	Coal ($\frac{4}{4}$ Seam)	0	3	7			
					22	1	6
27.	Sagre Clay	0	4	6			
28.	Grey Metal	4	3	7			
29.	Grey Post	5	0	0			
30.	White Post	0	5	7			
31.	Coal .. .. 0ft. 4in...						
32.	Band .... 0ft. 4in...						
33.	Coal, good .. 3ft. 0in... *Main Coal Seam*	0	4	2			
34.	Coal, coarse . 0ft. 6in...						
					16	3	10
35.	Sagre Clay	0	3	0			
36.	Coarse Coal	0	1	3			
37.	Grey Metal	0	3	0			
38.	Grey Post	3	0	0			
39.	Grey Metal	3	2	0			
40.	Coal	0	1	0			
41.	Sagre Clay	0	3	0			
42.	Grey Post	11	2	4			
43.	Blue Metal	1	3	0			
44.	Coal, *Low Main Seam*	0	3	6			
					21	4	1

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No.		Fas.	ft.	ins.	Fas.	ft.	ins.
45.	White Post	3	0	7			
46.	Black Stone	0	1	0			
47.	Coal	0	0	2			
48.	Grey Post	2	0	0			
49.	Coal	0	0	5			
50.	Grey Metal	1	0	10			
51.	Coal	0	0	5			
52.	Strong Grey Metal, with Post Girdles	1	4	0			
53.	Strong White Post	0	4	7			
54.	Dark Metal	0	4	6			
55.	Coal	0	0	2			
56.	Strong Grey Post	2	0	0			
57.	Dark Metal	1	0	0			
58.	Grey Metal	1	0	0			
59.	Coal, Brass Thill	0	1	6			
					14	0	2
60.	Sagre Clay	0	0	8			
61.	Blue Metal, with Ironstone Balls	5	0	1			
62.	Coal, *Hutton Seam*	0	2	5			
63.	Black Stone	0	0	8			
					5	3	10
64.	Grey Post	2	3	0			
65.	Coal	0	0	6			
66.	Grey Post, with Metal Partings	5	0	0			
67.	Black Stone	0	1	0			
68.	Coal	0	1	2			
69.	Grey Post	0	4	4			
70.	Grey Post, with Metal Partings	2	0	0			
71.	Grey Metal	1	1	6			
72.	Coal	0	0	6			
73.	Grey Metal	0	4	6			
74.	Grey Post	2	0	0			
75.	Black Stone	2	3	2			
76.	Grey Metal	1	3	0			
77.	Coal	0	0	1			
78.	Black Shale	0	0	9			
79.	Coal	0	0	6			
80.	Shale	0	1	3			
81.	Coal	0	0	3			
82.	Grey Metal	0	5	7			
83.	Grey Post	1	3	0			
84.	Black Stone	0	1	0			
85.	Coal	0	0	2			
86.	Black Stone	0	0	2			
87.	Coal, *Harvey Seam*	0	3	1			
					22	2	6
					161	1	3

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Mr. Stirrup said: The specimens of fossil fish lying on the table, sent by Mr. Bell, were found in the Marl Slate, No. 8 on section, and resting on the Lower New Red Sandstone. The marl slate was found to be 4ft. 5in. in thickness, which is about the usual in this district. Mr. Bell says: "It is very curious how little this marl has been noticed in Durham. Looking over a large number of sections in my possession I have never seen it mentioned, but occasionally it is called Blue Stone or Blue Metal. The New Red Sandstone at Deaf Hill contained very little water, indeed the Company are somewhat disappointed, as they hoped to find as much as would supply their colliery consumption. The only way to account for it, is the constant leakage of the tubbing at the other shaft, 60 yards off, and pumping out of the limestone for colliery use. This stratum contains the large feeders of water met with in our South-eastern portion of the Durham Coalfield, and which has been so expensive to sink through at many places, it varies in thickness from a few inches to 16 fathoms at Ryhope."

NOTES ON THE FOSSIL FISH FROM THE MARL SLATE.

By Dr. R. H. Traquair, F.R.S.

Palæoniscus Freislebeni.—Blaine.
Pygopterus Humboldtii.—Ag.
Dorypterus Hoffmanni.—Germar.
Acentrophorus glaphyrus.—Ag.

The greater number of the fishes from this section of the marl slate submitted to me by Mr. M. Stirrup belong to the well-known species *Palæoniscus Freislebeni* Blainville. This name was originally given and for long confined to the common *Palæoniscus* of the German Kupferschiefer, but there can be no doubt that it must also include the supposed species *P. comtus* Ag. and *elegans* Ag. from the English

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marl slate.* There are fragments of what must have been a large specimen of *Pygopterus Humboldtii* Agassiz, a name with which, in like manner, the terms *Sedgwicki* Ag. and *latus* Egerton, applied to English specimens, must also be considered synonymous.

One of the most interesting of the specimens in this collection is one of the rare *Dorypterus Hoffmanni* Germar, of which most unfortunately only the caudal half remains, the anterior part having been broken off and lost. So far as I know this is only the fifth occurrence of this remarkable genus and species in England, the four specimens previously found being contained in the museum at Newcastle-on-Tyne, and in the private collection of Mr. William Dinning, of that city. Originally described by Germar from the Kupferschiefer of Germany, *Dorypterus Hoffmanni* still remains a rarity also in that country.

There is also a specimen of *Acentrophorus glaphyrus* (Agassiz), the oldest known genus of the great semi-heterocercal series of Ganoid fishes which attained their maximum development in Mesozoic times. I may mention that I have recently, while on a visit to Germany, seen a specimen of this from the Kupferschiefer in the Geological Museum of the University of Hallé, under the charge of Professor von Fritsch. There can be no doubt as to the general identity of the fish fauna of the German Kupferschiefer with that of the English Marl Slate.

Mr. Dickinson: A good account of these Marl Slates was given by the late Professor Sedgwick, and it appears in one of the early numbers of the Transactions of the Geological Society of London. (1827, Vol. 3. Second Series, on the Magnesian Limestone.) I quoted from the account in my

* See A. S. Woodward, Catalogue of the Fossil Fishes in the British Museum, Part II., 1891.

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1873 report on the salt district in connection with the Middlesborough deposits.

Mr. STIRRUP: Sections where these marl slates may be seen are not so numerous as might have been expected. There is one on the shore at Cullercoats, near Tynemouth, where I believe Mr. Dinning obtained a number of his specimens. Their remarkable fauna of fossil fishes has been long known, and described in Mr. King's Monograph on the Permian Fossils of England. (Pal. Soc. 1850.) As Mr. Bell says that in sections of coal pit sinkings in his neighbourhood these beds of marl slate are scarcely ever mentioned. They are simply passed through by the sinkers without notice. It may be that they thin out in many places, and are therefore not taken notice of. The specimens exhibited are unfortunately many of them imperfect, but I suppose in sinking a coal shaft the securing of perfect ones is a matter of great difficulty.

Mr. DICKINSON: Of course these were only what were passed through in sinking.

Mr. STIRRUP: That is so. Those engaged in the sinking would not know there were any fossils in the rock till it was brought up to daylight, and thrown on the spoil-bank.

Professor DAWKINS moved a vote of thanks to the writers of the papers for their very interesting communications. I have the more pleasure in doing so because these specimens will be a considerable addition to the geological collection at Owens College.

Mr. DICKINSON seconded the motion, and it was carried unanimously.

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THE EARTHQUAKE SHOCKS OF 17TH AUGUST, 1892, IN THE BRITISH ISLES, AND IN CENTRAL FRANCE A WEEK LATER.

By Professor EDWARD HULL, M.A., LL.D., F.R.S.

The earthquake shock which was felt in the British Isles on the night of 17th August attracted such general attention that the author determined to investigate its force and extent from such information as was available, consisting of accounts in the public press, and letters of correspondents. These when tabulated and represented on a map of the British Isles proved to be of such interest that he ventured to lay the results before the Society.

The tract throughout which the shock was felt extends from the shores of L. Foyle near Coleraine in the North of Ireland—along a line stretching a few degrees E. of S. by Dungannon, Dundalk, and the coast of Ireland to Killiney—where the shock was comparatively severe; thence by St. David's Head and Pembroke Docks to the coast of the Bristol Channel; thence passing under the Bristol Channel it continues in the same S.S.E. direction—along the borders of Devon and Cornwall to the shores of the English Channel. The above appears to be an axial line—but the area affected spread over a considerable extent of the South-East of Ireland as well as South Wales, the Severn Valley and the South-West of England, including Devon and Cornwall. Particular enquiry had been made regarding the occurrence of the shock in the West of Scotland or the Isles, but from the answers received it was concluded that no shock had been felt.

The line above indicated points in the direction of Central France—including the old volcanic region of Auvergne—and being prolonged was found to point towards Sicily,

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where Etna was at the time in a state of violent eruption. This fact suggested a possible connection between the earthquake shock in the British Isles and the eruption of Etna. As if to confirm this view a shock, or succession of shocks, was felt throughout the Auvergne region just a week after that of the British Isles. One of these was registered at the Observatory on the summit of the Puy de Dôme—as stated in a letter to the author by the officer in charge—who determined the direction to be N.W. and S.E. A considerable area in the South-East of France was affected by this shock; but the author had been unable to ascertain that any shock had been felt in the Islands of Sardinia and Corsica, which lie in the line connecting Auvergne and Sicily. The chain of evidence—connecting the British Isles with Etna through Auvergne—is therefore incomplete; on the other hand, the prolongation of the axial line northwards would carry it to Iceland. As regards the immediate cause of the earthquake it seems probable that the occurrence of the new moon three days before may have precipitated the shock. as suggested by Sir R. S. Ball. A very curious point presented itself from time to time in reading the accounts—namely, that the shock was felt at one spot—and scarcely at all in the immediate neighbourhood. Thus the shock which was so severe at Killiney does not seem to have been felt in Dublin, about 7 or 8 miles distant in a N.N.W. direction. The explanation is probably geological. In the case of Killiney—which is built on a ridge of granite—we have the conditions required for the propagation of the earthquake wave of impact, (or shock) to the fullest extent. In the case of Dublin which is built over a thick deposit of boulder clay which in turn rests upon beds of soft shale and thin limestone the conditions are entirely different; and the effect of such soft, yielding materials at the surface would evidently be to deaden the shock—or entirely dissipate it;

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in the same manner as bags of sand have the effect of deadening the force of a cannon ball.

In conclusion, the author suggests that there is *prima facie* evidence of the existence of a line of a deep-seated fissure, or series of fissures, ranging from Sicily through Central France, the West of England and Wales, and the North-east of Ireland, along which earthquake shocks are likely to be felt from time to time, especially amongst the older and more solid rocks. Such a line would be parallel to that of the Appenines and the coast of Italy, which is connected with the Neapolitan volcanic system, but has no connection with that of Etna—as shown by the essential difference in the lavas of the two volcanoes.

Mr. STIRRUP (who read the paper in the author's absence) moved a vote of thanks to Professor Hull, which was seconded by Mr. DE RANCE, and passed.

Professor BOYD-DAWKINS: I feel considerable difficulty in discussing this communication, because in the first place it is assumed that the earthquake in question took place along a definite line which ran through Ireland and through the South of England. I should like to say that it is a pure assumption. There is no evidence of any description that the earthquake in Ireland and South-western and Southern England was of the nature of a vibration proceeding in one line. It was a vibration which affected a very large area, as compared with the small area of the British Isles; and as far as I know it was not felt as far South as the English Channel.* I do not accept it as proved that the earthquake proceeded along any line or series of fissures whatever. In the second place it seems to me that it is going very far

* Professor Hull states "the shock was felt along the coast of the English Channel, and that it produced very extraordinary effects about Exmouth and adjoining coast, as stated by numerous observers."

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afield to connect the new moon with earthquakes. It is impossible to believe that there is the slightest connection between the phases of the moon and earthquake shocks or volcanic phenomena. With regard to the vibration said to have taken place in Auvergne, in Central France, a week later, I do not think it has anything to do with this particular manifestation. We know perfectly well that the more observations are multiplied and observations increased earthquakes are continually being recorded all over the world; and I see no possible reason for assuming that that earthquake which is alleged to have taken place in Auvergne had any connection with the earthquake in the British Islands. At any rate there was a week's interval. Then, with regard to Etna, there was an enormous interval of space between the Etna eruption and this earthquake; and it seems to me perfectly incredible that the earth vibration in England could have had anything whatever to do with the eruption of a volcano in the far South of Italy; or that these two small areas could have been affected without the intervening country being affected also. I therefore am unable to accept this view of the connection between the two earthquakes and the eruption of Etna. Then there are certain other points which appear to me open to discussion in Professor Hull's paper. I hardly feel inclined to accept the statement that the chain of the Appenines is connected with the Vesuvian volcano. It is older than the volcano. Vesuvius is a thing comparatively of yesterday compared with the vast antiquity of the rocks comprising the Appenines.

The earthquake in this country was one which was very marked where it was felt. I, for instance, felt it. I happened to be down in Somersetshire at the time, and I had a feeling as if somebody lying flat under my bed had been trying to stand upright. I had felt the same feeling

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before, and I knew exactly what it was. I noted the time—it was between 12-30 and 12-35 (midnight). I merely rose to make these few remarks lest anyone should be led away with the supposition that there is any direct connection between the moon and earthquakes, or that there is any necessary connection between these two particular earthquakes and far-off volcanoes in Italy.

Mr. De Rance: There is just one observation I should like to make. In March, 1870, I think it was, there was an earthquake felt over a considerable area in Lancashire and Cheshire. I was waiting for a train in Preston, intending to go to London that night, and in the room with me were two other gentlemen, when suddenly we heard a noise as if a large cotton waggon were coming down the street. We were very much puzzled by the occurrence, because the street was a blind alley, along which there was no traffic; and we wondered if it could be an exceptionally heavy goods train passing over the viaduct. Only a second or two however passed before I felt a distinct wave-like motion in the floor. One of my friends, who was a Swedenborgian, said that the end of the world had come. "I think," I said, "it is an earthquake," and I took out my compass to note the direction of it, we instinctively made our way to the front door and had considerable difficulty in getting the door open, as it was more or less jammed. But my object in rising was not to narrate this personal experience, but to point out that the particular spot where I was—near the Barracks at Preston—was on the top of a plateau of drift, 120 feet above the river, resting on rock, as proved by the wells of the Brewery; and also to point out that the earthquake was felt with still greater force at Lancaster, where you also have a drift terrace on a rock bottom. This earthquake was felt there quite as badly, if not worse, on the drift, as it was in Ormskirk, which is built

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on the rock. So far, therefore, as my small experience goes, it is not in accord with the suggestion of Professor Hull.

Mr. Stirrup: I am glad Professor Dawkins has said what he has done with regard to Professor Hull's paper. I think it is rather late in the day to attempt to connect earthquakes with lunar phenomena or even with volcanic eruptions, because I do not think the point is at all settled that earthquakes, speaking generally, have any connection directly with volcanoes. Many earthquakes take place in districts far removed from volcanic areas. The connection between the two phenomena in non-volcanic regions, has, in most instances, never been satisfactorily traced. I have a paper here which was sent to me by Mr. Davison, of Birmingham, respecting an earthquake that was felt in the neighbourhood of Manchester in 1889. Mr. Davison wrote to me for some information which I was able to supply to him from a paper by Mr. John Knowles, published at the time in our Transactions. The earthquake which was felt near Manchester and round about Bolton, and further north, was referred by Mr. Davison entirely to mechanical disturbance, arising from a slip of the great Irwell valley fault. From all the information that could be gathered at the time, it was found to be a movement along the line of that fault. He also found that some Scotch earthquakes, felt in the same year, followed similar fault lines, the conclusion arrived at, being, that they were merely mechanical displacements, connected with the geological structure of the country, and not attributable to volcanic action. The connection that Professor Hull suggests between the manifestations in England and Ireland with the earthquake shock which occurred a week later in Central France is very doubtful, I do not see the connection at all; it seems to me the evidence is entirely inconclusive on that point.

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Mr. WOODWARD: I felt the shock distinctly that Mr. Stirrup has referred to in the Irwell Valley. I happened at the time to be close upon the red rock fault.

Mr. STIRRUP: Gentlemen who observe such phenomena would greatly assist us if they would take notes at the time of such occurrences, and send them to us. It is desirable in all cases to have the observations registered. They may at some future time be valuable.

Professor BOYD DAWKINS: I listened to the observations of Mr. Stirrup with much pleasure. What he has told us about the great Irwell fault exactly squares with observed phenomena in Troon to the south of the Caledonian Canal. In that district they have a small earthquake area to themselves. The opinion I have always held is that that great line of smash which is marked by the valley in which is situated the Caledonian Canal is still on the move, deep down in the rocks; and from time to time there is a sudden rifting of the rock below which causes a vibration. That observation with regard to the great Irwell fault is of extreme interest in relation to this question, and with regard to the general theory of earthquakes. I thank Mr. Stirrup for bringing it forward.

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TEMPERATURE OBSERVATIONS IN A DEEP COALPIT SINKING IN BELGIUM, WITH ANALYSIS AND TEMPERATURE OF A SPRING OF WATER AT A DEPTH OF 3,773 FEET.

(Per M. X. Stainier.)

Communicated by Mr. Mark Stirrup, F.G.S.

M. Libert, an engineer belonging to the Belgian Administration of Mines, has just made some interesting discoveries in the course of sinking a deep shaft for a coalpit in Belgium, of which my friend M. X. Stainier, of Brussels, has kindly sent me the following particulars, thinking they might interest the members of the Manchester Geological Society :—

"The Colliery Company, of 'Charbonnage des Produits,' at Flénu (Borinage), has just deepened its shaft, Ste Henriette (No. 18), to the depth of 1150 métres = 3773 feet.

The coal workings terminate at the depth of (650 ms.) 2132·6 feet; there is therefore (500 ms.) 1640 feet of virgin ground.

The mouth of the shaft is 246 feet above the level of the sea.

Several measurements of temperature at the bottom of the shaft (3773 feet) have been taken in a borehole, of which the following are given :—

16th Oct., 1889, the temperature was + 47° C. = 116·6° Fahr.
21st Dec., 1889, ,, ,, ,, + 44·5° C. = 111·2° ,,

Cross-cuts have been pushed to north and south at the level of 3773 feet.

The cross-cut to the north has reached 705 feet.

At the face of this cross-cut, a spring of water has been met with at a temperature of 48° C. = 118·4° Fahr.

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In the south cross-cut a borehole has given (31st December, 1890,) a temperature of 40° C. = 104° Fahr.

From the temperature experiments the mean increase of temperature would be 1° C., or 1·8° Fahr., for 29 m. 61 cm. = 97 feet, or 1° Fahr. for 54 feet.

This average agrees perfectly with that obtained by M. Cornet (Proc. Roy. Soc., Lond., 1886, Prestwich).

M. Cornet got a mean value of 29·65 m. = 97 feet 4½ inches per degree C. = 1·8° Fahr.

The spring of water in the north cross-cut, previously referred to, and which had a temperature of 118·4° Fahr., has shown on analysis an extremely remarkable composition, as follows:—

The density, or specific gravity, at 18° C. or 64·4° Fahr. was 1·040 (that of sea water being usually given as 1·026).

The fixed residue per litre amounted to 59·800 grammes.

(1 Gramme = 15·4323 grains troy.
1 litre = 0·2201 gallon, or 1·761 pint.)

Analysis.—Per litre.	Grammes.	Grammes.	Per cent.	Per cent.
Carbonate of Calcium	0·716		= 0·0716	
,, Magnesium	0·184		= 0·0184	
,, Iron	0·006		= 0·0006	
		0·906		0·0906
Sulphate of Calcium	0·468		= 0·0468	
,, Magnesium	14·352		= 1·4352	
,, Sodium	0·052		= 0·0052	
		14·872		1·4872
Chloride of Calcium	2·868		= 0·2868	
,, Magnesium..... ..	3·092		= 0·3092	
,, Sodium	38·029		= 3·8029	
		43·989		4·3989
Iodide of Sodium.....	0·015	0·015	= 0·0015	0·0015
Silica	0·018	0·018	= 0·0018	0·0018
Total	59·800	59·800	5·9800	5·9800

This water comes from a bed of sandstone, and the flow was 18 cubic mètres per 24 hours."

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In reply to Mr. Ward,

Mr. STIRRUP said: The writer does not give particulars of the rocks at all. If he had stated what rocks were penetrated, it would have added much interest to his communication.

Mr. WILD: In sinking at Bardsley, in 1863, we reached the old mine 545 yards deep, and in driving these dip brows the coal gave off a little water. This water was just about as salt as the water after the first washing of cockles. I took as much of it as filled a saucer full and allowed it to evaporate slowly. It left a deposit of the thickness of a sixpence all over the saucer. This water was present all the way in driving from the upper to the lower shaft, a distance of 100 yards.

On the motion of Mr. STIRRUP, seconded by Mr. WOODWARD, it was decided to postpone the discussion upon this paper.

LIST OF SHELLS FROM THE LOWER BOULDER CLAY AT HEATON MERSEY, NEAR MANCHESTER, WITH REMARKS THEREON.

By MR. CHARLES ROEDER.

I alluded in a previous short paper (Part XX., Vol. XXI.,) to a deposit of laminated clays which occur at Messrs. Peter Bailey and Sons' Brick Works, at Heaton Mersey, near Stockport. Since then, I have repeatedly visited this locality to examine this artificial section. From an inspection of the 6in. Geological Map of that district, to which I beg to direct your attention, you will observe that this large brickyard is situated almost upon the boundary line of two formations. It rests on the Triassic pebble-beds, and a little to the East stretches in a direction North and

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South, a small narrow strip of Permian marl, bounded to the East by a great and extensive fault with a downthrow North-east, of about 300 feet. East of this we come upon the Upper Mottled Sandstone of the Trias. It is useful to keep these circumstances in mind in discussing the character of the boulders which are embedded in the clays to be seen in this area. To the South we encounter a succession of alluvial gravel-terraces connected with the River Mersey, and the glacial clays are capped with a deposit of fine blueish-grey, often contorted and folded sand, 10ft. thick, resting on a layer of peaty matter, 1ft. thick. The level at which the clays occur, is about 150ft. above the sea. After this rapid outline of the nature of the "country," I shall pass on to the description of the deposits I wish to illustrate.

Immediately following the peaty layer we find a fine bed of laminated, book-leaf, or gutta-percha clay; I have not been able to measure the exact thickness it reaches, but put it down as from 13ft. to 15ft. It is worked off in small step-terraces from the top downwards, on the Northern side with a levelled floor, hence the access for study is very easy. There is no false bedding, or folding, and the layers run in regular, horizontal succession and uniformity. In peeling off layer after layer, merely divided by impalpably thin sand partitions, we come to the conclusion that the formation is no doubt owing to slow and gradual deposition of films of clay emanating from trickling sheets of muddy water, which issued from the ice over the clay surface beneath. It was a continuous and long-repeated process. The colour of the clay is of a yellow-brown, there are no faults or slickensides observable along its range, the deposit is perfectly free from any stones, pebbles, or other foreign bodies, the fine intervening sand films are very micaceous and frequently show thin layers of coal grains. Recently I

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have been so fortunate to meet with two large pockets, 3ft. by 4ft. long, of reddish, slightly gravelly sand, in the laminated clay. The interest of these nests consists in this, that *in* them I have for the first time discovered specimens of *Polyzoa*, probably belonging to the genus *Salicornaria* and *Lepralia*, and remains of some *Marine Algales*, together with two fragments of *Nucula*. Hitherto *Polyzoa* have only been found by me in the glacial sands at Ramsey, Isle of Man (North shore) which I have brought for comparison, and also at Caldy, near West Kirby, Cheshire. They have besides been found in the so-called Upper Clays at Newton-by-Chester by Mr. Shone, and at Caithness, and other parts of Scotland. These pockets were unfortunately too disturbed for tracing their physical structure. The laminated clay appears sometimes ripple-marked, and is characterised by a total absence of shell-remains, or Microzoa of any kind, at least I have washed it frequently without results. With regard to the extension of this very valuable bed, I am not in possession of sufficient data to pronounce how far it expands in each direction, and of what shape it may be, but for practical purposes it seems as yet to be far from exhaustion. It is in this locality that it is best developed in the neighbourhood of Manchester. I have found them often sporadically at Cheetham Hill, Harpurhey, near Clifton Junction, in small intercalated masses, frequently extremely contorted and fractured, but too insignificant to work with any advantage. After heavy gusts of rainfall, such as lately experienced, the exposed face of this clay is cut up by innumerable rills and rifts, the sand films yield under the pressure and are washed out, the whole mass becomes undermined and is set moving, and a talus of soft puddle fringes the foot of the slope.

Below the laminated clay we have a stiff, heavy, deep-

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brown clay. There is no clear boundary separating them, but a heavy rain sharply brings out its stoney composition. At present the section is not well suited for scrutiny of the contact of the two deposits, namely, if there is any erosion or cleavage. I must leave this point for another occasion. The clay produces, on washing, a large percentage of gravel and sand. The boulder stones are mostly of small size, seldom exceeding 19 × 12 × 6in. Of Granites (black and white) there are but few instances; the preponderance is held by the weathered greenstone, and scratched, ground, and polished Carboniferous limestone. Next in number follow Wenlock sandstone, quartz porphyrite, clay ironstone, and out of a heap of some hundreds of stones I have only counted six specimens of New Red Sandstone, four from the Coal Measures, and four pieces of well-scratched and grooved Permian Limestone and sand stone, but *no* Spirorbis limestone. Remembering that the brickyard lies closely on the boundary of the Trias and the Permians, the apparent scarcity of rocks from this quarter becomes very striking. All the rocks found are mostly angular or subangular. I have exhibited on the table specimens of this washed clay, showing the gravel and sand gained from it. It is composed mostly of rounded plates of coal shale and sandstone, fragments of greenstone, New Red Sandstone, and angular, rounded, and polished quartz grains. The thickness of the clay is estimated at about 27 feet, but the base has not been reached, consequently we cannot ascertain at this stage what look the floor presents, whether the Trias is grooved, ploughed, or shattered, and also whether the boulders lower down are different to those in the higher parts.

These clays contain a comparatively rich mass of shell material, and since my last communications I have been able to add considerably to the previous list. Of 116 fragments collected the following have been identified:—

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18 *Turritella terebra* = 16%
14 *Cardium edule and echinatum* = 12%
9 *Tellina balthica* = 10-12%
5 *Mya truncata* = 4%
2 *Nucula sp.*
3 *Astarte sulcata.*
1 „ *compressa.*
2 *Leda sp.*
1 *Artemis sp.*
3 *Mactra sp.*
2 *Modiolus sp.*
2 *Pleurotoma rufa.*
1 „ *turricola.*
1 *Trophon truncatus.*
2 *Buccinum undatum* (bits of columella).
2 *Fusus* or *Purpura* (bits of columella).
1 *Cyprina Islandica* (very fragmentary).
47 more or less distinct fragments.

I also join some details about the state of the shells themselves :—

No united valves *in situ* have been found.

Some fragments could be fitted.

No shells encrusted with barnacles, &c.

The material filling the spiral univalves does not differ from that of the surrounding matrix.

No Microzoa found inside the shells or clay.

There are only two complete shells (one bivalve and one univalve out of 116). Some of them are showing the holes left by a burrowing sponge, *Cliona.*

All the fragments look as if they had been broken and worn on a shingly beach. Of Boulders, none are found encrusted with Serpula, Polyzoa, &c., or showing evidence of any boring.

For the naming of the shells I am indebted to the kindness of Mr. R. D. Darbishire.

A vote of thanks to Mr. Roeder was passed, on the motion of Mr. Wild, seconded by Professor Boyd Dawkins.

Mr. Dickinson asked if all the shells of which specimens were exhibited were all of existing species.

Mr. Stirrup: They are.

It was resolved to take the discussion upon Mr. Roeder's paper at a future meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XXII. SESSION 1892-93.

THE ORDINARY MEETING of the Members was held on Tuesday, March 14th, 1893, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

WILLIAM SAINT, Esq., H.M.I.M., Vice-President, in the Chair.

FOSSIL PLANTS FROM THE CANNEL OF THE WIGAN FOUR FEET MINE.

Mr. STIRRUP said the specimens of fossiliferous cannel on the table had been sent by Mr. Caldwell in response to the circular which had been issued to the members, mine owners, and others. They were accompanied by the following letter :—

Moss Hall Coal Company, Limited,
Moss Hall and Low Hall Collieries,
Near Wigan, February 24th, 1893.

MARK STIRRUP, Esq., Manchester Geological Society.

Dear Sir,

Referring to our conversation after the last meeting of the Manchester Geological Society at Wigan with reference to the numerous plant remains found in the cannel portion of the Wigan Four Feet Mine at our Low Hall Colliery in the township of Abram, I now, according to promise, send you a few pieces which may interest you. One long piece (20in. by 12in.) is a very good specimen, and I am sorry I cannot send its counterpart, which was equally good, but it

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has been exposed to the weather, and has lost its marks. The other pieces are just ordinary samples, such as may be found in any day's get.

This cannel in the Wigan Four Feet Mine is peculiar to the township of *Abram*, and has been worked for several years largely by the Abram Coal Company, and to a less extent by the Moss Hall Coal Company, and the Wigan Junctions Colliery, in Abram, and by a few others to a limited extent just outside Abram, but the bulk of the unworked portion is in lease to the Moss Hall Coal Company. It is found thickest about the centre of the township, in some instances as much as 6ft. to 8ft. thick, and in some isolated cases even more than that, but always tapering off, however, near the boundaries of Abram at thicknesses of from one foot to a mere trace, into the adjoining townships of Hindley, Ashton-in-Makerfield, Golborne, and West Leigh.

I send you one piece where the cannel is thin to show you how it lies between the top and bottom coals, being attached to both without any parting, and the section of the mine from whence that comes is, say, top coal, 8 inches; cannel, 4 inches; and bottom coal, say, 3 feet; total, 4 feet.

The top coal is nearly always about the same thickness, say from 6 inches to 8 inches, and where the cannel thickens, the whole mine is thicker to that extent, or nearly so, generally. The bottom coal, which averages say from 2ft. 9in. to 3ft. 3in., does not vary much from that, but where the cannel is thickest, the upper portion of the bottom coal, viz., that nearest the cannel, partakes largely of the nature and the appearance of cannel, and, as seen underground, might be easily mistaken for the cannel itself. I have not observed any plant remains in the coal, either above or below the cannel, though there may be. I may state that the gas made from this cannel is of very high illuminating power, and the price of the cannel at the pit during the past year has been 40s. per ton.

I remain,

Yours faithfully,

GEORGE CALDWELL.

Mr. Stirrup added that he understood the point of interest with regard to these cannel specimens was the frequent presence of vegetable remains. They often found fish remains in cannel.

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Mr. WILD: Stigmaria are commonly found in the cannel. Nearly all these markings are those of stigmaria.

Mr. CALDWELL: I do not know that I can add anything to what I said in my letter. I am not a geologist, but I thought these specimens might be interesting to the members of this body. It is a curious thing that when you split a block of this cannel, markings of some kind are very often disclosed. The cannel burns very freely, and a thin chipping held in the hand will light readily with a match.

Mr. JAMES GRUNDY: I beg to move a vote of thanks to Mr. Caldwell and Mr. Johnson (who had also sent in some coal fossils) for their kindness in sending these specimens. As most members are aware the Committee appointed by the Council to take in hand this matter of collecting carboniferous fossils would like to get as many as possible of such contributions; and it is only by the members, and friends of members throughout the country, following the good example of Mr. Caldwell and Mr. Johnson that we can hope to carry out the work we have undertaken.

The motion was seconded and carried unanimously.

Mr. CALDWELL, in acknowledging the vote of thanks, mentioned that the Wigan Junction Colliery Company had raised a large block during the previous week, which they purposed sending to the Chicago Exhibition. It was 9ft. long by 8ft. wide, and 5ft. deep; and its weight was from 10 to 12 tons.

Mr. WOODWARD: I understood Mr. Caldwell in his letter to say that when the cannel was thick, the coal—which I I take it, underlies the cannel, if it is anything like the cannel in the Manchester district—was thinner.

Mr. CALDWELL: This cannel is part of the Wigan Four Feet Mine. It is different altogether from what is known as the Wigan cannel.

Mr. WOODWARD: We find the reverse takes place, for

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where the cannel is thin the bituminous coal is thicker. Where the cannel is thicker the bituminous coal is thinner.

Mr. CALDWELL: The upper portion of the bottom coal so nearly resembles cannel, that, as stated in my letter, it may easily be mistaken for it; and Mr. Woodward's description might consistently be substituted for my own.

Mr. WILD: What is the difference in horizon between the Wigan Four Feet and the Cannel Mine around Manchester?

Mr. WOODWARD: All the information I have, and all the sections I have, indicate that the cannel mines in this district would correlate with the cannel mine in the Wigan district. I think the cannel mine in the two districts is used as a datum line, so to speak, for all the other mines in the district. Overlying that cannel mine is what, with us, is known as the *Trencherbone*, which is the Wigan Nine Feet. This Wigan Nine Feet is the seam which, some years ago, got rather a bad name, and they changed it to the Wigan Six Feet.

Mr. CALDWELL: Mr. Woodward is quite correct as regards the Wigan Cannel Mine, but this Wigan Four Feet Mine or Abram cannel is certainly not from the cannel mine which is underneath the *Trencherbone*. The Wigan cannel mine proper is thickest under Wigan, but it thins out in the neighbourhood of the Moss Hall Collieries, and becomes very thin indeed; whereas, the Abram cannel thickens. This cannel which is now shown is from a mine 120 yards higher up than the Wigan cannel, and locally forms a part of the Wigan Four Feet Mine, which is 30 yards above the Wigan Six Feet or Trencherbone Mine; it is not found in the same mine in any township except Abram; therefore to distinguish it from the other Wigan cannel we call it the Abram Cannel. It is thickest in the centre of the township, as I have explained in the letter, and when you get to the outside of the boundaries it tapers off to a mere trace.

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Mr. Barrett: It is a great deal richer than the ordinary Wigan cannel, and more expensive. The ordinary cannel is not nearly so valuable for gas-making purposes.

Mr. Caldwell: The ordinary Wigan cannel has not this fracture at all. This Abram cannel has not only a different fracture, but also a higher illuminating quality. The Wigan cannel has a conchoidal fracture, but the Abram cannel is distinctly laminated. Commercially, you have to compare about 40s. per ton for the Abram cannel with about 24s. for the Wigan cannel at the pit.

Mr. Johnson: In Wigan itself the cannel mine is about 30 yards deep under the Parish Church. It extends under Haigh Hall, on to Aspull, and as far as Westhoughton, tailing out very thin and getting worse in quality. As Mr. Caldwell says, the mine they get this cannel from is in a different seam altogether to what they call the Wigan Cannel Mine.

Mr. Stirrup: Are these characteristics you speak of constant, Mr. Caldwell? Could you tell the product of your seam distinctly from any of the Wigan cannel?

Mr. Caldwell: Oh, yes.

Mr. Stirrup: Perhaps Mr. Clay will tell us whether he finds plant remains in the cannel of the Dukinfield Coal Company?

Mr. Clay: Yes, as well as fish.

The Chairman: It is gratifying, I feel sure, to Mr. Stirrup and the Council to know that a beginning has been made in the collection and transmission of fossils; and it is desirable that the members and their friends assist as far as they can, and enable us to complete the work.

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ON THE DEEPENING OF A SHAFT AT HULTON COLLIERY, LANCASHIRE.

By Mr. James Tonge, F.G.S., Assoc.M.Inst.C.E.

This paper, giving an account of the deepening of a shaft at Hulton Colliery, is not brought to the notice of this Society because of any supposed superiority over other methods, but simply as showing one way of sinking during the night without interfering with the winding of coal during the day.

The pit in question is one of a pair, situated at Chequerbent, belonging to the Hulton Colliery Company.

No. 1 is the Downcast, and is 200 yards deep, to the "Three-quarters" mine which is being worked there.

No. 2 pit, of which we have to speak, was an Upcast; but was only down to the "Yard" mine, a depth of 140 yards.

It was thought desirable to sink this pit down to the "Three-quarters" mine and so make it the upcast for that mine as well as for the "Yard."

But as it was not convenient to stop the working of the "Yard" mine it was decided to go on with sinking only in the night.

The pit was 12 feet diameter, brick lined, and there were two cages carrying two tubs each.

There were four conductors, and these were fixed diagonally across cages, and tightened by heavy iron weights in the sump hole.

As the cages were each 3ft. 2in. wide and 7ft. 4in. long, with 16in. clearance between cages, it was very clear that there was not room for the ordinary sinker's wagon or "jiddy" as it was termed, to be run across the pit without some alteration in the position of the conductors.

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How to alter the conductors so as to entail little cost at the beginning and so as to be most convenient whilst sinking and coal winding were being carried on alternately night and day was the problem to be solved.

After considering the various circumstances and conditions that might reasonably be expected to arise, the following course of procedure was fixed upon, and carried out:—

1. It was decided not to disturb, or interfere at all with either of the winding pulleys in the headgear, or with either winding rope or cage; that during winding over the sinkers the two cages should remain attached to the ropes and run up and down the pit exactly as when winding coal.

2. That the dirt should be wound up *one side* of the shaft only.

3. That the dirt should be wound up to the Yard mine in the hoppets, and be there emptied into tubs.

4. That as it was not possible that the cage could go below the Yard mine an additional length of rope equal to the depth to be sunk should be attached to the winding rope previous to sinking each night, and detached after sinking.

5. That to make room for the "jiddy" to be run across the pit, the outside conductor should be removed to the other side of the cage.

These were the only alterations required. They may be briefly summarised thus:—

1. Taking weights off conductors after securing them by screws at the top.

2. Attaching a short connecting chain to the end of the winding rope to hang permanently until sinking was completed, and getting 60 yards of rope to be attached to the chain each evening and detached each morning.

3. Moving one conductor; drilling holes in the cage for thimbles; taking out one bearer from the sump hole and

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putting two bearers at the Yard mine for the wagon to run on.

The whole was carried out exactly as decided; no alteration or deviation was found to be necessary, and no accident or hitch of any kind occurred to render the plan in any way objectionable.

The procedure each evening, after coal winding, was as follows:—

1. To lift the cage from over the sump.
2. To take off the scaffold planks covering the sump.
3. To run the wagon over, upon which stood the hoppett with the 60 yards of rope coiled round.
4. To couple the rope to the end of the short chain under the cage.
5. To lift the cage slowly whilst the rope was carefully lifted from around the hoppet.

Preparations were now complete.

Time occupied, 20 minutes. On completion of sinking each morning the time occupied in preparing for coal winding was the same, but in reverse order, of course. During the night, as each hoppet of dirt was sent up, it was emptied into tubs, as already noticed, and run along a level road as far as required, say, 100 yards at farthest, or an average of 50 yards.

The empty tubs were left ready each evening after coal winding was finished.

The sinking was always finished about four o'clock, and a couple of men were appointed to send up to bank the dirt got during the night by the sinkers.

This was considered to be the only weak point about the work, the emptying into tubs and running them along the road into the "Yard" mine, and then fetching them back to put in cages. But this loss was estimated to be more than recouped by the facility with which the dirt was got

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rid of at the surface through being in tubs. A little handy jig ran the full tubs down a brow to a dirt heap, and brought the empties up with great despatch.

And there was much less winding over the sinkers' heads, and the banksman was nicely within speaking distance.

The plan adopted was found to be satisfactory to owners, managers, and men, and when afterwards a second length was to be sunk the same plan was again adopted.

The sinking was commenced on August 4th, 1890, and the 60 yards was completed on December 9th following, and the shaft lined with 9 inch brickwork, set in mortar and made solid behind brickwork with concrete, the brickwork being laid upon iron rings supported by iron plugs driven in the sides.

A vote of thanks was unanimously passed to Mr. Tonge for his paper.

Mr. James Grundy said: There was one point in the paper that attention might be drawn to. Mr. Tonge says that, in the bricking up, they built the whole thing solid: they did not put in any loose ashes or anything of that sort, but built it up of bricks and concrete. I think I am right in that?

Mr. Tonge: Yes.

Mr. James Grundy: It is a point worth noting. Managers might consider, when having shafts lined, whether it is not best to have them bricked solid. If a part gave way the whole thing would not tumble in, providing really good mortar was used. I know a case where some brickwork fell in, and they were compelled to take all the rest out and build it afresh. One would like to have heard from Mr. Tonge something about the preliminary proceedings—for instance, whether all the ropes, &c., having regard to the extra strain upon them, underwent a process of overhauling, to see if they were all perfectly sound.

The Chairman: Perhaps Mr. Tonge can say what was

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the relative weight of load when the cage was working, and when they were raising dirt in the hoppets.

Mr. Tonge: There would not be a great difference. The dirt that came up in the hoppet was generally two tubs full. The apparatus was well able to bring up that, with a large margin over. As to the hoppet, there was not a great difference in weight between that and the two empty coal tubs. Of course the cage was as before; but there was an extra length of rope, 60 yards. Still we never reckoned to run them anything near so close a calculation. We considered that we had an ample margin, and everything was quite strong enough. I may, in answer to Mr. Grundy, say that the chains were changed just before we began sinking. That was a necessary precaution, chains are things that are liable to receive sudden damage. As to the packing, I am glad Mr. Grundy mentioned it, because it is a matter to which I attach great importance. I myself had to do with a shaft where 20 yards of the pit fell in, and when it came to be examined it was found that it had originally been backed up with ashes, and that a great deal of the backing had at various times fallen out. There were a large number of hollow places, and the brickwork was not a full nine inches or anything near it. Ever since that time I have made a very strong point of it, and am particularly careful to see that there is a perfectly solid wall all round the shaft. I believe that to be a perfect protection against the sides falling in.

Mr. Isaiah Johnson: I have had to do with a lot of shafts in my time, and I always found it most satisfactory to build some good brickwork, at least nine inches (though perhaps less would have done) and back that with ashes, in preference to making anything solid. If any weight came, no matter if the brickwork was three feet thick made solid, it would crush it just the same as if it was nine inches made solid.

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Mr. JOHN GERRARD: One point strikes me in connection with this practical paper, and it is this. Mr. Tonge said one of his difficulties was how to arrange the guides. I wonder if it never crossed his mind to make use of the guides for sinking. It would have facilitated the winding, both as regards greater security and the greater number of journeys, had he made use of two of these guides to guide the hoppet.

Mr. TONGE: It was only when considering what we should do that we experienced any trouble. We thought we had made a most satisfactory job, and we used the guides as far as the Yard mine, the cage always running up and down the conductors just as in winding coal.

Mr. H. A. WOODWARD: It is a very common practice now to sink pits with guides. With regard to bricking, I find, as a rule, that a practical sinker will corbel out his brickwork, and take hold of the projections by which the shaft is surrounded, so that there should be no chance of the brickwork running down. If you put in only 4½in. brickwork you cannot possibly do that; but with 9in. brickwork you can have headers and stretchers, and corbel out so as to take a firm hold of the Measures.

Mr. THOMAS GRUNDY: At the Wigan Junction Colliery we had occasion to sink to the Wigan six-feet, a distance of about 28 yards, and there in place of a "jiddy" we used a pair of falling doors, worked by levers, which we found were more effective. Mr. Tonge might have found that a much better arrangement. They would have needed no changing of the rods, and the running of the "jiddy" must certainly take a longer time than the changing of the doors. The changing of the rope and making preparations for the sinkers resuming work, from four o'clock in the afternoon to five in the morning, took only about eight minutes, compared with 20 minutes on Mr. Tonge's system.

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This was afterwards continued to a depth of about 120 yards. If the work would interest members of this Society, I should be glad to make a few sketches and read a paper at a future meeting.

METHOD AND VALUE OF FOSSIL COLLECTION IN COAL MINING.

By Mr. George Wild.

The importance of an acquaintance with the fossils and other special lithological characteristics of the strata forming the roofs and floors of coal seams, as well as in the partings which often separate seams of coal worked as one mine, cannot be over-rated. Though often the great advantage of a local practical knowledge of their sequence may be possessed, yet, from the uncertainty regarding the occurrence of displacement by faults, which may be encountered in sinking, and which may disturb the most careful calculations as to the position of the seam or seams which constitute the object of the undertaking, something more than a knowledge of the order of the strata, and thickness and quality of the seams of coal, is essential to ensure a fair measure of success in ascertaining the position, after crossing a large fault. Especially is this the case in unproved ground in the immediate locality.

Not only do many beds of sandstone vary in thickness, texture, and colour, within a limited area, but shales, and bands of ironstone, as well as the the coal-seams themselves, often alter to such a degree as to render them unrecognisable by ordinary observation. Strange beds may be intercalated, or familiar ones be absent, perplexing the most practical miner. Under such circumstances we cannot possess too many test-points. We cannot bring to bear too many corroborative testimonies, for or against, to lead us to a

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right conclusion, an object which often means salvation from ruin to the proprietor, and a blessing to the district in which the undertaking is situated.

It is not only in shaft-sinking, but also in tunneling and extending the underground workings, that these difficulties present themselves, and, in the absence of some special knowledge for guidance, frequently end in misfortune.

In order to assist those who desire a more intimate acquaintance with the occurrence of fossil organic remains of plants, shells, and fishes, I offer the experience of a great many years observation in the coal-mines of the district.

The occurrence of plant remains, though often found in the roof, or within a few feet of a coal seam, are by no means confined to that position, but are found in almost every kind of strata, and in all positions in relation to the coal seam itself. Plants other than Stigmarian roots and rootlets are, however, rarely found immediately underlaying a seam of coal which possesses what is commonly called a fire-clay seat.

Taking the distinct changes of strata, I have found plants other than those just mentioned, occur, in one district, in about 12 per cent. of the beds, whilst the occurrence of Stigmaria depends much upon the number of coal seams, thick or thin. I have found them under 85 per cent. of the beds of coal in this district, though they are to be found in the mass of both coal and cannel seams, and occasionally above the seams, when Sigillaria and Lepidodendra are present.

As the examination of the roof of a coal mine is an important and oft recurring part of the duty of underground officials, the practised eye is brought in daily duty directly upon the most favourable situation for acquiring an intimate knowledge of the forms of fossil remains, if any,

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accompanying the seam or seams of coal under the official's supervision, and the least an inquiring mind would lead him to do, for his own and his employers advantage, would be, to make notes of the various forms occurring over or in connection with such seams. I can well understand a person hurrying through a mine daily and not being acquainted with the subject of these remarks from want of a little observation and a slight acquaintance with the names and nature of the different forms to be met with, and I may say, I have found a great improvement in thoughtfulness—keenness of observation in every respect, and higher tone of character in all officials who gave a little attention to the points here spoken of than they previously possessed.

Fossil shells are as rarely found immediately under coal seams as Stigmaria above, but are met with often in the shales immediately overlying, as well as in many ironstone bands, and shales comparatively free from grit or sandy matter. Many of the shells are very important from a diagnostic point of view in the determination or recognition of seams of coal.

It is very important, in collecting fossil shells, to note the position in which they are generally found, as regards the shells themselves as they lie in the shale or other matrix, and not to throw away single valves, as they are sometimes of great value in distinguishing doubtful species, and therefore adding to the value of them for both practical and scientific purposes.

Care should also be taken not to knock off the outer coating of shelly matter for the same reason, as many splendid specimens have been rendered almost valueless, from having the outer markings destroyed in order to bare some beautifully pyritized or smoothly polished surface, leaving the fossil only a cast of the shell.

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The habitat of Anthracosia, Anthracopterygia, and Modiola would seem to have been such situations as favoured the formation of smooth dark shales, and the upper portion of cannel seams. They are also met with in smooth blue shales in the roofs of coal seams, free from plant remains, which indicates a preference for quietly accumulating mud. They are occasionally associated with fish remains in the dark shales.

Fossil fish remains are sometimes met with a distance from a coal seam, rarely in blue shale except when enclosed in nodules or bands of ironstone. Black shales are the most likely strata to meet with them, and the most common situation, immediately on or over a seam of coal or cannel, however thin the seam may be. The large spines, Gyracanthus, Ctenacanthus, Pleuracanthus, Orthocanthus, and allied species, are generally met with immediately on a coal seam, and mostly with the heavy side downwards, and the same may be said of the larger scapulæ, whilst the vertebræ are, as a rule, laid flatwise, as are also the palate plates Ctenodus, and the larger jaws and teeth of other species. The teeth Pleurodus and allied species are also most commonly found on the coal, and the hollow side upwards. Where the roof consists of dark shale, and its separation from the coal is clean, and not slippery or smooth from disturbance, the remains of fishes are most easily found in the mine.

They are generally coated over with a thin film of shale, which, however, does not often obliterate the form, and a practised eye can detect at once the nature of the fossil projecting from the roof. A slight blow or two with the pick-hammer, generally carried by the fireman, will dislodge the Pleurodus and other small specimens, which are seldom larger than a pea or a horse bean, whilst larger ones require a little cutting round before it is safe to attempt

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to bring down the matrix containing them. A half-dozen specimens, which may have been marked with chalk by an observant collier or the fireman in his first round, may often be got out in as many minutes.

Should the shale be in the habit of falling in thin flakes, a good opportunity is presented for finding the lesser varieties of fish or plant remains. Some of the fossils seem to be characteristic of certain seams or beds of strata in the Lancashire measures, and, when such is the case, are both practically and scientifically valuable.

Unless the party possessing the specimens, of whatever kind, be an experienced collector, it is unsafe to attempt to clean them in any way, as the hidden, and often most important parts, may be destroyed from want of a knowledge of their position on the specimen. These remarks apply chiefly to the Lancashire coal measures, and are the result of nearly half a century of occasional collecting in the North and South-Eastern portion of that field. Allow me again to repeat, that the elevation of character and competency which has many times followed the acquirement of an intimate knowledge of the subject of this brief paper, by not only underground officials and managers of mines, but also proprietors of mines and others entirely unconnected with coal mining, warrants me in believing that much good would accrue to both the individual who takes it up, the proprietors of mines, and the scientific public generally.

Mr. Stirrup moved a vote of thanks to Mr. Wild. He said: The communication is one which comes very appropriately before us at the present time, and as it really includes the experience of so long an acquaintance with the coal measures, we value it very much. To some of our younger members, and those who may be inclined to help

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us in our plan of getting together a full number of the fossils of the Lancashire coal measures, this paper will be of great assistance, and I have no doubt Mr. Wild has had in view the helping of those who may not exactly know how to go about fossil collecting.

Mr. CALDWELL seconded the motion, which was passed unanimously.

ON SOME RECENT ESTIMATES OF THE WORLD'S COAL SUPPLY.

BY MR. MARK STIRRUP, F.G.S., F.I.INST.

In the discussion which followed the recent address of Professor Boyd Dawkins, "On the Coal Fields of New South Wales," which the Professor told us occupy an area considerably greater than the united coalfields of the British Isles, I took occasion to refer to an estimate of the World's Coal Supply, which appeared on the same day (27th January, 1893), in the London *Standard.*

This was the telegraphic summary, from their Berlin correspondent, of a just issued report by a Prussian Mining expert, to which special prominence was given, and to which attention was drawn by a leading article on the subject. The communication is as follows:—

"Herr Nasse, the Prussian Official Mining Expert, has just published the result of his investigations into the probable duration of the coal strata of the World, and an estimate of the amount of the present contents. He believes that the coal strata of Europe, excluding Russia, those of Austro-Hungary, France and Belgium will be exhausted first—in five centuries at most; then those of Great Britain; and finally those of Germany. He anticipates the American supply will not last longer than the European."

In the editorial article accompanying this summary, it is

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remarked that "Any calculation of this kind must necessarily partake of a speculative character, especially when comprehending so wide an area as in the present instance."

With this remark, I think, the members of the Manchester Geological Society will all agree, seeing the diverse opinions that have been promulgated from time to time, as to the duration of the coal supply of the British Islands, a compact area, of limited extent, and whose geology has been well worked-out. It seems a somewhat hazardous speculation, therefore, to estimate the *World's* coal supply, vast regions of which have never been surveyed or explored for the purpose of estimating their concealed mineral wealth. Not having seen the text of Herr Nasse's report, I do not know his reason for excluding Russia from his estimate of the coal resources of Europe. It cannot be on account of her poverty in that respect, as she possesses large coalfields in the Donetz basin of the South and elsewhere.

In considering the future of Europe in connection with the world's coal supply, one must not neglect to take into account the immense coalfields of the East,—India, China, and Japan, and their probable influence in the near future on the continuance of the supremacy of the West.

Before the termination of the five centuries or less, which, according to Herr Nasse, is to see the exhaustion of the European coalfields, and the consequent decadence of the power and commercial advantages which the Western nations at present possess, changes in the path of Empire may have been brought about by the awakening of the Eastern nations to the knowledge of their strength with the possibility of throwing off the dominance of the Western world. This revolution, predicted by that philosophic thinker, and able writer, Dr. G. Le Bon, in his work on the

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"Civilisations of India," will be brought about, he says, not by the might of cannon, but the field of battle will be the the market-halls and marts. Under the influence of steam and electricity, Dr. Le Bon goes on to say, the nations of the earth are daily being brought into closer contact, the result of which will be a general equalisation of the value of industrial and agricultural products, and consequently of wages over the surface of the globe.

Now, in such a competition, the Orientals, who form the majority of the inhabitants of the globe, and who are at the same time of all people the soberest, will inevitably become the regulators of wages.

Already the wheat of India is sold in Europe cheaper than our own grain. What will it be when manufactures shall be beaten in their turn in our Western world by nations making goods as well as ourselves, thanks to our own machines and at prices twenty times less?

The miner who is accustomed to spend five or six francs a day, and who threatens to shake the social edifice because he is not getting more than three or four, will soon see manufacturers asking from China, then open, for coals hewn by men who believe themselves rich when their daily wages reach five or six sous.

The operatives who strike work in order to raise their wages will no longer find employment, because these same coals will feed in the extreme East manufactories supplied with our machinery, worked by men happy in gaining a sum twenty times less than that asked by Europeans, and whose produce will inundate the world."

That all this is not a dream, is manifest in the gradual increase of cotton mills in Bombay and other parts of India and also in Japan, which latter country, with Tonquin, are already exporters of coal and rivals in the Eastern markets, once served by British producers only.

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Returning however to the coal resources of the East, China, it is well known has immense reserves of coal, for the most part undeveloped, Japan is also richly endowed with the combustible, and the recent acquisition of Tonquin by the French has led to the discovery of rich coalfields in that country which are now being opened out and worked by French and English capital.

Of the extent and value of these coal deposits of Tonquin, Prince Henry of Orleans, who visited them last year, speaks in the highest terms.

The principal deposits now being worked at Hong-Hay and Kebao are supplying the markets at Hong Kong and Singapore with good furnace and steam coal.

Respecting the extent of the coal deposits of Tonquin, Prince Henry says "the next geological map of the country will be marked by a wide black band traversing the colony in its greatest extent from south east to north west; appearing in the Isle of Hainau, at Kibao, at Hong-Hay, then in the Dong-Trieu, at Quang Yen, and again upon the banks of the Red river, at Yen-Bay, at Lao-Kaï, where the trials have revealed a combustible equal to the best Cardiff. These deposits have been traced as far as the province of Yunnan, forming veritable mountains of coal."

"Tonquin, says the Prince, quoting the words of Lord Connemara, is called to play the role in the extreme East, that England plays in Europe, and that will be the great coal producer of Asia."

Turning now to the consideration of Herr Nasse's assumption that the American coal supply will not last longer than the European, one is at a loss to know upon what statistical or other evidence he bases his belief.

Certainly, such a computation is opposed to all our previous conceptions of the great extent and richness of the

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coalfields of the United States and the Dominion of Canada, some of which fields are practically untouched.

The resources of the United States, when considered as a whole, are as yet imperfectly known, as the surveys are not completed.

It is only in the Eastern States—those earliest colonized—where the mineral wealth of the country is satisfactorily made out and computed.

As the tide of immigration has been driven further and further west, so have the various regions been explored, with the result of finding rich coalfields in close proximity.

Many of the valuable coal deposits of the Central States, in the Mississippi province, are scarcely touched, and only need capital for development and ready outlets for the coal to become a power in the world.

It would, however, far exceed my intention, in referring to this subject of the World's Coal Supply, to give even a summary description of the resources of each State of the Union so far as at present known; all that I purpose doing now is to offer some little evidence at hand in disproof of Herr Nasse's view of the speedy exhaustion of the American coal resources.

For this purpose I have selected a few official statistics of some of the Western States, including those bordering on the Pacific.

Alaska.—Commencing with Alaska, the most northerly possession of the United States (purchased a few years ago from the Russian Government), it is known from recent surveys and explorations that the country is rich in coalfields, as well as other minerals.

In the report of the Governor of Alaska to the United States Government for year 1888, mention is made of official visits to some of these deposits on the seaboard. Within the arctic circle, coal seams crop out at many places along

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the coast between Cape Lisburne and Point Lay, and miners have reported immense out-cropping seams—mountains of coal—in the interior on the banks of the Yukon River and its tributaries.

In Yakutat Bay at the foot of the St. Elias Alps, coal has been reported, and coal seams have been worked on Admiralty Island and the Prince of Wales Islands, on the South East coast of Alaska.

But the principal supply of Alaska coal has been, so far, from Coal Bay on the Eastern shore of Cook's Inlet, 25 miles North East from Port Graham, the place where the Russian-American Company's mine was located.

In this neighbourhood the coal measures frequently outcrop along the shore for a distance of nearly 100 miles. The coal is of excellent quality and has been shipped to San Francisco and other points along the Pacific slope, and it is expected that ere long sufficient coal will be mined to satisfy all the demands of the coast.

The Alaskan coal mines possess advantages of being contiguous to tide-water and commodious harbours and the Governor in his report asserts that there is coal enough in Alaska, and of the very best quality, to supply the wants of the whole of the Pacific Slope for centuries to come.

That this recent addition to the known coal resources of America will be largely augmented is certain, as the mineral wealth of the territories yet unsurveyed, becomes better known. As an evidence of this I purpose to refer, as briefly as possible, to those less known Western States, which from their more recent colonization, the public is less familiar.

Our acquaintance with the Western States of the Union and those bordering the Pacific is, as a rule, confined to their known richness in metalliferous ores, Gold, Silver, Copper, Lead, &c., but as these ores have been worked, explorations for coal have been made for the reduction of the ores and

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other purposes, resulting in unsuspected deposits of coal being brought to light.

I shall just refer to a few of these States, quoting from recent reports of their respective Governors to the Secretary of the Interior.

In Washington territory adjoining British Columbia there are several large coalfields being successfully worked, the coal, in the main, being rich bituminous. Coal-mining, says the Inspector, is destined to be an important factor in the development of the territory.

Of Montana, the Governor reports inexhaustible fields of coal, some of which, near the railroads, are being actively developed, and coals placed on the market.

The adjoining Territory of Wyoming is said "to abound in coal, and it is found in every county in the territory, sometimes cropping out on the banks of ravines, creeks, and streams, and nowhere at such a depth as makes mining very expensive." For most part bituminous, adapted to all domestic purposes, as well as for locomotives.

Of the mineral resources of Dakota, that of coal occupies a prominent place, including as it does "vast coal deposits, which, while in no way equalling, exceed in extent the coal deposits of Pennsylvania."

Among the undeveloped resources of New Mexico, the principal among these, says the Governor, are our coals, the character of which are anthracite, lignite, and bituminous. He speaks of the coal measures of the Territory as "of very great extent, aggregating fully 4,000 square miles of at least 10 foot veins of coal. This vast store of latent steam power, in connection with a corresponding deposit of all the precious and useful metals, usually found in immediate or convenient proximity to this coal, indicates, of itself, the

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establishment here sooner or later of very important manufacturing industries."

Of other of these Western States, as Utah and Colorado, the same tale of undeveloped coal resources might be told, but I think I have quoted sufficiently from official statistics to disprove Herr Nasse's opinion of the American supply of coal following rapidly in the wake of his predicted exhaustion of the European coalfields.

Of the central and eastern territories of the United States and their immense coal resources I have not attempted to collate, as of their value the public is better acquainted. The Dominion of Canada is also well known to be rich in coal, the extensive coal basins of Nova Scotia, New Brunswick, and Newfoundland having long been exploited near the seaboard on the East coast, and there are large supplies in Vancouver Island and British Columbia on the Pacific side. The result of this rapid and imperfect survey scarcely bears out the dismal prospect of a world without coal in five centuries to come, which if such a consummation were even likely to be realised within that period, the coming exhaustion would make itself felt long before in almost prohibitive prices and much consequent suffering.

The 19th century owes much to scientific discovery, but a substitute for coal is as yet a desideratum, which nature's laboratory has not yet disclosed nor the ingenuity of man provided. Natural gas and rock oils, the only heat and light producers which have come into competition with coal are too sparsely and sporadically distributed to take its place, and these natural products are also being rapidly exhausted in many of the regions where these resources have been found and tapped.

A vote of thanks was given to Mr. Stirrup for his paper, and discussion upon it was postponed.

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JUN 20 1893

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XXII. SESSION 1892-93.

THE ORDINARY MEETING of the Members was held on Tuesday, April 11th, 1893, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

Mr. ROBERT WINSTANLEY, Vice-President, in the Chair.

NEW MEMBER.

Mr. JOHN RIGBY, Mining Engineer, Winsford, having been duly nominated, was balloted for, and unanimously elected an Ordinary Member of the Society.

THE GLACIAL DRIFT DEPOSITS AT SANDBACH.

Mr. DE RANCE said: I wish to state for the information of the Society that the London and North Western Railway Company are widening their line between Crewe and Stockport, and the first contract has been let to Messrs. Monk & Newall, Contractors, Liverpool, who have got the matter now well in hand. In the progress of these works, at Sandbach, a magnificent section of the sands and gravels of the Glacial Drift—the finest in some respects I have ever seen—has been laid bare. I am sure many members present will be

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glad to hear that these sands and gravels show what, after a very extensive experience on my own part, of drift sections, I have never seen before, that is the presence of faults in the glacial drift, (Mr. De Rance illustrated this on the black board)—there is (he continued) a bed of rolled drift-coal, faulted eight inches by a fault subsequent to the deposition of the glacial drift. Now, when you follow this drifted coal seam a little further you find it suddenly terminated, and that a second fault has come in, and in the space of six feet, I noticed, this morning, seven different faults, of a few inches each, throwing the beds a little bit down; the seventh fault is the master fault that cuts off the drift coal bed, and trough faults occur just in the same sort of way as we have faults in the coal measures. So although these faults are very small, (the main fault eight inches, and the others half an inch, or an inch), we have a most distinct case of true faulting occurring since or during the glacial epoch, which ever it may have been. In addition to the faults, it is worth while for members to go down to Sandbach (and the sections are within 400 yards of the station, and some even within the station itself) to see a curious example of what Mr. Hugh Miller, in one of his papers read before the Scotch Geological Society, in which he follows in the footsteps of his distinguished father, describes as "fluxion structure." They are made up of a series of fine sands with rolled coal, and every now and then there is a little nodule which turns out to be consolidated sand and gravel, and round that particles have been arranged in lines of fluxion structure which have surrounded the hard points; and in addition, as we proceed northward that is towards Sandbach station there is remarkable evidence of the way in which the beds are drawn out, the rolled coal beds, in an elongated fashion, as if a heavy weight had passed over the material and the material of the

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different gravels had sorted themselves together, and they had been dragged out in the direction of the flow. In support of that I found, this morning, several pebbles intensely glaciated, some of them seven or eight inches long. It is a very rare thing to find pebbles glaciated in the sands and gravels. The marks on the Sandbach specimens are very sharp, and in the long axis of the stone were in the directions in which the drag of these coals had taken place. I would strongly advise anyone who may wish to see this section to go to Sandbach at once, as there is very great probability that it will soon be removed.

On the motion of the HONORARY SECRETARY, seconded by Mr. WILD, the best thanks of the meeting were given to Mr. De Rance for his interesting communication.

FOSSILS FROM THE LOWER COAL MEASURES.

Mr. STIRRUP called attention to a collection of fossils (exhibited upon the table) from the "Shale Bed" seam of the Rishton Colliery. The fossils had been sent by Mr. P. W. Pickup, in response to the circular recently issued by the Society. Mr. Pickup wrote respecting them, as follows:—

Rishton Colliery,
Rishton, near Blackburn,
March 11th, 1893.

M. STIRRUP, Esq., Secretary Manchester Geological Society,
36, George Street, Manchester.

Dear Sir,

In response to your circular of January 9th, relating to the fossils of the Lancashire and adjoining coalfields, I beg to inform you that I

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have this day forwarded to your address carriage paid a specimen section of the "Shale Bed" seam as it is found at this Colliery.

It is peculiar from the fact that above the pure coal there is a layer of the roof shale varying from 2ft. to 2ft. 6in. in thickness, filled with streaks of coal which are quite full of plant fossils.

We have found the plant impressions to be most prolific and in the the best state of preservation at about a foot above the top of the pure coal.

The "Shale Bed" seam is 176 yards deep in the winding shaft of this Colliery, and is 32 yards below the Lower Mountain or Gannister Mine.

Below it (the "Shale Bed") is 5in. of coarse Fireclay, beneath which is a strong white rock, thickness not proved here. I consider this "Shale Bed" is the "Salts" or "Bassy Mine" of Mr. Binney's Section, and the white rock under it to be the equivalent of the "Woodhead Hill Rock."

The seam is not workable in this district, and its only remarkable feature is the zone of shale streaked with coal, full of plant fossils, which makes it easily recognisable.

For your further information, I have enclosed in the box with the section a number of these fossils, which have been taken from a point close to where the section has been got, and which will show you what the streaks of coal are like when split open.

These impressions you will see are more remarkable for their abundance than for their size or clearness.

Yours truly,

Per pro P. W. Pickup,

WILLIAM PICKUP.

A vote of thanks to Mr. Pickup was unanimously passed.

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ON OUTBURSTS OF SOFT COAL AND GAS IN THE ROYLEY SEAM, AT THE NOOK PIT, BROAD OAK COLLIERY, ASHTON-UNDER-LYNE.

By Mr. Joseph Dickinson, F.G.S.

The outbursts of soft coal and gas which I am now, with the full sanction of Miss M. Maiden, the owner of the colliery, about to bring under notice, are taking place from a seam of coal in the working of which the dèbris is extremely liable to spontaneous combustion. Almost every pack which is made for the support of the roof heats; and if the heat does not decline of itself after attaining a certain temperature, but continues to increase, and the pack cannot be cut into and the heating matter removed, it ignites and has to be dealt with under increased difficulties.

It is the Royley seam of coal that is being worked. It is the lowest in the middle or main series of the Lancashire coalfield at Ashton-under-Lyne and Oldham.

The section of the seam averages about :—

	ft.	in.
Inferior coal and dirt	0	6
Impure soft coal with sulphur combinations	1	6
Hard coal, 20 to 24 inches	1	10

The shafts were sunk to it about the year 1870, the deeper one being 296 yards. The strata dip west at the rate of one in one and a half (or two in three) from the outcrop to about 500 yards on the dip of the main shaft, beyond which the inclination becomes not quite so steep.

The impure soft coal is called the "minings" or holing coal, it being the bed in which the miners hole during the working. It contains nodules of iron pyrites with other

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combinations of sulphur and impurities, locally called "chemics"; and as it has little, if any, value as fuel, and is the principal material available for packing and would not apparently pay to send out, it is used for stowing into the packwalls to support the roadways and the roof. It is the substance which in the pack occasions the spontaneous combustion; and it is the bed that during the working becomes forced out, as outbursts, from the faces of work.

This soft coal generally gives off very large quantities of firedamp in new drivings, so much so that even on the level course safety lamps have to be kept out of the holing. The firedamp is not generally what is known to miners as sharp firing gas, it being apparently mixed with black damp of some kind, but it fires in the lamp.

In order to find out the best way of surmounting the combined difficulties of the spontaneous combustion, the firedamp with other gases, and the thinness and steepness of the seam, a variety of methods of working have been tried. The result of the experience is that it is found best to slide the coal down from the rise workings to the tramroads, using iron shoots in some of the brows called "tin-brows," to avoid narrow work so far as practicable, to have the ranks or ranges between main levels about 100 yards apart, to have the main levels, and recently the engine brow, driven about 10 or 12 yards in width, with a packwall at each side, the horse road in the levels having a space left below the lower pack for a temporary intake for air, and another space above the higher pack for the return air. It has also been found best to have the packs formed in blocks of four or five yards square, with sufficient room between that they can be gone round and watched, so that if spontaneous combustion occurs the pack can be readily cut into, and, if needed, cleared out. Also, when working back the range of coal left between

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main levels, to have similar packs left behind in the goaf or worked out part, and to keep roadways there so that the packs can be gone round for about three months, after which time the liability to heat generally ceases.

When a pack is beginning to heat and gob-stink is smelt from it in the return air, the firemen track it out, and when the place is reached holes are cut into the pack, and if needed, the heated part is shovelled out. Experience has shown in the case of this heating, that if the seat, when found, be dry it is likely to fire, but if moist it seldom fires. Also, that in this mine fire seldom ensues until about a fortnight after the first indication of stink.

It is also found best not to leave any piece of wood, brattice cloth, nor such like thing that will readily ignite, in the goaf or pack.

In this way, the difficulties mentioned were for a time got over successfully. The coal on the rise was first worked, and it was not until working began on the dip by means of an engine brow, and a depth of about 500 yards below the surface attained, that outbursts of the soft coal commenced.

The outbursts have all occurred when the men were present. They come out of the faces of unworked coal in new drivings. Some have occurred in wide and some in narrow work, some in driving downbrow and some upbrow, and some on the level course both north and south. They have also occurred during continuous working, and on resumption after intermissions of two or three days, and both with and without boreholes in advance.

The engine brow is driven on the "end" or "cleet" of the coal, which is here about 27 degrees north of the full dip. This slanting direction occasions the entrances of main levels from the engine brow to be about 120 yards

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apart; and the levels on the north side to form an obtuse angle on the rise and an acute angle on the dip as they leave the engine brow, the levels on the south side leaving the engine brow with the obtuse angle on the dip and the acute angle on the rise. The consequence of this is that the engine brow lower down diverges from the south levels and leaves more solid coal for firedamp to drain from than what is left below the north levels; and as a fact, possibly owing to this, more of the outbursts have occurred at the south side.

Some warning is generally given before an outburst occurs. There is usually some crackling of the coal, or the coal is more fissile or curly, or more gas is given off. When the outburst takes place it is accompanied with more or less noise; the noise in some of the instances being described as like the beginning of a peal of thunder, or like steam blowing off from a boiler, and it has been loud enough to be heard 100 yards away in the mine. The soft coal comes out chiefly in the form of dust, and is accompanied with firedamp apparently mixed with some chokedamp, and sometimes there is a little haze. The spaces left behind are in zig-zag form, as shown on the accompanying plan. Judging by the quantity of soft coal thrown out, and from no cavities having been found where boreholes were in advance, the issues come out of solid ground.

The first outburst that attracted notice was when the workings had attained the actual depth of 498 yards below the surface. It occurred in the month of May, 1885, in No. 4 north level, at 160 yards from the engine brow; the bed of soft coal being forced out from the lower corner for about 16 feet in advance of the face.

After this, in October, 1885, when the same level was 280 yards from the engine brow, a much larger and more

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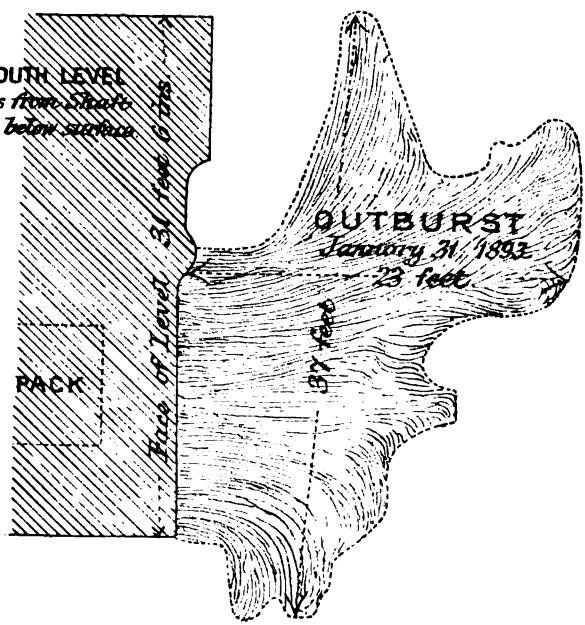
Trans. Man. Geo. Soc. Part VIII. Vol. XXII.
To illustrate Mr. Dickinson's paper.

500 Yards from Shaft Level.

On.

Scale of this part of the Plan
12 Feet to an Inch.
Three lives lost.



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alarming outburst occurred, which caused the workings to be discontinued for a time.

Work was resumed; and in 1888, in No. 4 south level, at about the same depth of 498 yards below the surface, a succession of outbursts occurred. They commenced May 1st, at 144 yards from the engine brow, and continued May 10th; June 11th, a small one; June 15th, a large one that came out from the face of a narrow thrill which was being driven up to another level, the soft coal being forced out to within one yard of the higher level; June 25th one, a large one which occurred in the day shift, and another, a small one, in the night shift; June 27th, a small one in the counter level on the rise of the main level. Then in the main north level, at the same depth below the surface, August 12th, 400 yards from the engine brow, a small one in a thrill; and August 28th another.

In some of these outbursts one or two men became buried up to the armpits with the soft coal which issued, but up to this time not any life was lost.

Afterwards, in extending the engine brow below No. 4 levels, small quantities were frequently forced out, without any particular account of them being kept.

When the engine brow had reached a greater depth below the surface the outbursts began to assume a more serious form and fatal accidents ensued.

The first fatal accident was on May 2nd, 1890. The outburst came out of the face at the bottom of the brow, about 575 yards below the surface, where the brow was only five feet wide, and it left an area of about 144 square feet whence it came. The soft coal shot up into the brow where two men were at work, and it, together with the gas,

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smothered one of them and fastened the other so that he was unable to get from under until rescued by the fireman, when going his round.

The second fatal accident occurred July 22nd, 1890. The burst came out of the face of a thrill only four and a half feet wide that was being driven upbrow out of No. 5 north level, about 570 yards below the surface, and 59 yards from the engine brow. It drove the miner against the prop to which the front of the brattice cloth for air was fixed, where he was found smothered underneath the dust. The space left by this outburst was 16 feet 6 inches in length, by from three to six feet in breadth towards the left hand, besides some on the right. A large quantity of firedamp came off with it, which took some time to dislodge. The noise accompanying this issue, as described by a miner who was working near, was like the beginning of a peal of thunder.

The following nine serious but not fatal outbursts occurred in No. 5 south level.

November 25th, 1890, at 140 yards from the engine brow, where the level was five yards wide. It came out of the rise corner, just where a thrill was being commenced.

In 1891, January 19th, where the level was 10 ten yards wide, 214 yards from the engine brow. In this instance the soft coal and gas came out of the face with a noise described as of steam blowing off from a boiler, which was heard 100 yards away. The gas extinguished safety lamps, and the miners who retired into fresh air had to wait half an hour before the gas disappeared.

February 3rd, 250 yards from the engine brow, the outburst being smaller.

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March 9th, from the face of a thrill between three and four feet wide, a few yards above the level, about 250 yards from the engine brow. It occurred with a loud noise which died away in a few seconds; and it left a cavity 13 feet long by three feet wide at the front and four feet at the inner end. The soft coal fastened a day-wageman but did not seriously hurt him. The gas extinguished the safety lamps, five in number, and took two or three minutes to disperse.

March 31, about noon, in the counter level on the rise of No. 5 level, the soft coal blew off from 12 feet of the face for about four feet in advance. There was in the hard coal underneath the outburst at two feet from the higher side of the level a borehole 5ft. 9in. long. The borehole was left intact.

April 23rd, at 8-30 p.m., in No. 5 south level, 400 yards from the engine brow. The soft coal from the face at the higher side blew out from six feet in advance, the space left being four feet wide at the outside and two feet at the inner end. There was a borehole six feet long in the hard coal underneath. The site of the outer end of the borehole for about one foot in length was blown off, but the inner five feet were left unmoved.

July 10th, at 4-45 p.m., 460 yards from the engine brow, the soft coal blew out, leaving a space eight feet long by two feet in width at the outer end and four feet at the inner end, like a bottle, with the neck outwards. There was a borehole 11ft. 4in. in advance of the face near the high side of the level, but the outburst came from close to the low side. The men who were at work near the low side escaped on the dip of the pack walling, but one of the men from the high side was overtaken by the gas which over-

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powered him for a time. In about fifteen minutes the gas cleared away.

July 16th, where the soft coal was holed or mined into, and there was a borehole 9ft. 10in. in advance of the mining, the soft coal blew out from four feet in advance of the mining.

July 22nd, in the same south level, where it was ten yards wide with two packwalls, the soft coal burst out from four feet in advance of the upper part of the face. There was a borehole six feet in advance going through the part of the soft coal that burst out, and there was also another borehole about three yards lower down eleven feet in advance. The outburst brought away with it part of the upper borehole.

During the time when these latter outbursts took place, the pressure in No. 5 range was gradually lessening, and had almost ceased to operate. The actual pressure as tested in some of the boreholes with the entrance tightly closed round the testing pipe, being reduced to eight-tenths of an inch of water, as shown by the water gauge.

In 1892, operations were commenced to extend the engine brow for the present lowest range at No. 6 when, as anticipated, greatly increased pressure was met with, and the outbursts re-commenced with vigour in the "live" or "quick" ground.

I should state that the foregoing 22 outbursts occurred during my tenure of office as Inspector, and each one received my personal careful attention and consideration. They were also carefully considered with Mr. Mills, the Manager that has since died, and with Mr. Robert Waddicor, the Under-Manager; and also with Mr. John Higson, the Consulting Mining Engineer and his Acting Assistant,

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Mr. Lawton. There was also a conference with Miss Maiden, the Owner; Mr. Higson, Mr. Lawton, Mr. Mills, myself and a Deputation of Miners' Agents, including Mr. Samuel Woods, M.P., and Mr. Robert Isherwood. I also conferred with Mr. William Saint and Mr. James Grundy, Assistant Inspectors of Mines, on some of the later outbursts, and with Mr. Joseph S. Martin, Inspector of Mines, on the earlier.

For the information respecting the following four outbursts which occurred during the commencement of No. 6 range, after I had retired from the inspection, I am indebted to the kindness of Miss Maiden and Mr. Higson.

July 21st, 1892, in a thrill that was being commenced to cut through into the back brow at the north side of the extended engine brow, the soft coal blew out leaving a space of about 19 feet by 12 feet. A borehole was afterwards bored 15 feet into the face, and on the pressure in it being tested it showed at first on the Saturday 2lbs. per square inch, and on the following Monday 14½lbs. per square inch. It was then decided to resume boring, and if pressure was shown to stop the place until the escape of gas ceased, so as to reduce the pressure, and generally to drive slowly.

The third fatal accident was on October 1st, 1892, in which a miner was smothered. It was from the face of a narrow driving that was being made upbrow, to meet the back brow, near the north side of the engine brow 129 yards on the dip of No. 5 rank. The soft coal burst out, leaving a space 20ft. 6in. by 11ft. beyond the face of the brow, the face of the brow being seven feet wide. From the information it appears that the miner having struck the face with his pick, the face cracked and he ran away. He waited about five minutes and returned. He gave two more blows. It cracked again. He came out and waited about

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eight minutes. He then went in again and resumed working, and soon after his son heard a low report, followed by a loud one, and saw his father running down the place, and then he could see nothing but dust, in which and the gas the father was smothered.

The fourth fatal accident was on January 31st, 1893, in No. 6 south level, 41 yards from the centre of the engine-brow, at about 700 yards down the brow, the depth below the surface being more than 600 yards. About 30 tons of the soft coal burst out, with, as usual, a large quantity of gas, in which three miners lost their lives. It came out from the lower half of the face where the level was ten and a half yards in width, the upper half of the face being left standing, but the outburst extended fully five yards on the rise beyond this upper part, whilst on the dip it extended about two yards below the lower side of the level. The total length of the outburst from rise to dip was 37 feet, and the extreme breadth from where the face had been to the far end 23 feet. It happened on a Tuesday at 10-45 a.m., after the place had been standing since 1 p.m. on the preceding Saturday, 66 hours. The under-manager at 10-15 a.m. on the Tuesday sounded all along the face with a hammer; and the fireman was entering when the outburst came. It put his and other men's lamps out, and blocked up the air-course. The three men who lost their lives were working at the lower part of the face. Two other men who were in the upper part escaped. No warning sound nor any gas had been noticed until the crack of the outburst came. There was not any borehole in advance.

March 9th, 1893, from the face of No. 6 north level, 75 yards from the engine brow, and about 700 yards down the brow. The level was 16 yards 9 inches in width, with the horse road between two packs, an intake for air below

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the lower pack, and a return air course above the higher pack. This outburst came from the lower part of the face. It extended ten feet on the rise and nine feet on the dip of the lower side of the level, total 19 feet, and the extent inwards was 14 feet. Mr. Ramsden, the new manager, was in the place between 10 and 11 a.m., and found it all right but giving off gas very freely all along the face. He ordered a borehole to be made as a test hole, and it was six feet three inches in at 11-35 a.m., when the drilling was stopped, the face continuing to give off gas very freely. At 12-20 noon, the miner heard the coal cracking. He retreated, and looking back saw the soft coal coming out like a great wave, and more followed. Two men working near said a cloud of mist formed. The outburst dislodged the site of the borehole.

The first precaution thought likely to prevent or alleviate the outbursts was boring in advance to let off the pressure. This is an old practical procedure, and under normal circumstances it has the effect of greatly mitigating the pressure of firedamp upon the coal, roof and floor. But it has not proved successful with this bed of soft and impure coal. Endeavours were made to keep the boreholes 15 feet in advance, but that was found impracticable, as they became either damp or choked, or they fretted with the issue of gas.

It soon came to be suspected that the boring was not much if indeed any preventative at all. The outbursts occurred indiscriminately, both with and without boreholes. Some occurred between two borings. Others drove away the actual site of the holes. That the pressure could be so let off was also discredited by the outburst that extended to within one yard of an upper level where under ordinary circumstances pressure of firedamp would have got vent.

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The suspicion adverse to the utility of boreholes then became extended to the possibility that the boreholes by admitting air into this impure coal with its known liability to spontaneous combustion might aid the absorption of oxygen, and thus, by occasioning heat and expansion, do more harm than good.

In order to test whether the boreholes induced heating, the temperatures outside and inside several of the borings were taken under varying circumstances. In most of these the temperature was a little higher in the borehole, the greatest difference being 5 degrees Fahrenheit; but in some of the instances the temperature outside was higher than in the hole. The deduction therefore, so far as any could be drawn from these experiments, was not in favour of boring.

An evidently useful precaution has been found in keeping the space behind the miner as clear as possible from tubs, brattice, props, or other obstacle, in order that a clear course may be left for escape.

The miners were also enjoined to be on the alert, and to leave the place in the event of anything unusual occurring; also to inform the fireman, and have warning given to persons in the return air which might be affected by the issue of gas.

The effect of driving out slowly has also been considered and tried, hoping that the pressure of gas might drain off gradually. The conclusion to be drawn from this is indefinite. Some of the outbursts have occurred during the continuance of active work; but others were where the places had been standing from the Saturday at noon until the resumption of work on Monday and even until the Tuesday following.

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An opinion has existed that if in working the coal the holing or mining in the soft coal be extended more than two feet it tends to make the soft coal "quick" beyond and to bring on an outburst. Holing more than two feet underneath is therefore forbidden; but whether this prohibition really affects the conditions necessary to produce an outburst is at present, like some of the other things connected with the phenomena, problematical. It is at any rate an experiment to find out the cause.

Recently, Mr. Higson has had samples of the soft coal or "minings" analysed, and he and Miss Maiden have each courteously furnished to me the result, of which the following is a copy:—

"Chemical Laboratory, Royal Institution,
Manchester, March 13th, 1893.

Messrs. J. & P. Higson, Booth Street, Manchester.

Gentlemen,

We have submitted to careful analysis the four samples of Minings which you sent to our Laboratory, and which we have marked 1 to 4 and have found them to contain:—

	Percentages.			
	1.	2.	3.	4.
Fixed Carbon	46·71	12·25	43·50	0·97
Volatile Matter	17·97	17·03	17·69	6·82
Mineral Matter	20·47	47·83	24·87	89·58
Sulphur which burns away	13·81	22·08	13·10	0·94
Moisture	1·04	0·81	0·84	1·69
	100·00	100·00	100·00	100·00
The Mineral Matter contained Sulphur	Trace	0·14	0·41	Trace
Equal to Iron Pyrites, Fe. S2.	25·89	41·40	24·56	1·76

The above figures shew that the samples in question which we marked respectively, 1, 2 and 3, contain large quantities of Iron

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Pyrites. No. 4 is composed chiefly of clay, and contains only a small percentage of that substance. The bi-sulphide of iron, when exposed to air and moisture or water, absorbs oxygen from the air with such avidity as to become red-hot, and we think it probable that the accident you mention in your note is due to the rapid oxidation of the Pyrites which is contained in such large quantities in the samples under those conditions.

On blowing the powdered samples Nos. 1, 2 and 3 into a gas burning from jet, they ignite rapidly, producing a large amount of flame; but there appears to be no great difference between the flame produced by them and that produced by any other coal dust.

We remain, your obedient servants,

(Signed,) CRACE-CALVERT & THOMSON."

In sending me these analyses Mr. Higson, referring to my being about to read this Paper before the Manchester Geological Society, says that perhaps I may deal with the question of boring, as there is amongst some of the mining persons of the district an impression that boring would be a preventative of these outbursts; and he adds: "You and "I, however, have sifted this matter fairly to the bottom, "and our theory of the boring being a source of danger is "fully borne out. The Chemist points out that the balls of "bi-sulphide of iron seize with avidity upon the oxygen "contained in the air, water, or moisture, and so become "almost red-hot; and as you and I are aware there can be "no heat of that intensity without enormous expansion you "have at once an explanation of the outbursts, and it must "be somewhat gratifying both to yourself and myself that "we focussed the point without the chemical knowledge we "have gained from the analyses. This, I think, settles the "question beyond all doubt of the absolute uselessness of "boring. It is only a waste of time and money, and it may "have a tendency to create a confidence on the part of the

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"operative miner which ought not to exist, as I have no "hesitation in stating that, in my opinion, boring will not "prevent in the slightest degree these outbursts."

To these remarks of Mr. Higson, which are very much to the point, I may add that these outbursts differ in many aspects from those which occasionally occur both in deep and shallow mines from pressure of firedamp alone, in which experience shows that letting it off by boring in advance is useful.

The nearest resemblance to these outbursts are two described to me by Mr. J. S. Green as having happened under his management in the black vein of coal at Celynen colliery in Monmouthshire. The first of these, in which a miner was smothered, occurred in 1879, in a part of the workings under the mountain where the depth was about 440 yards; and the second occurred in 1880, when a horse was smothered, also under the mountain, at a depth of about 425 yards. The seam of coal at the time was giving off firedamp very freely, and the outbursts came from faulty ground where the coal was soft or rotten; but the mine was not like Nook—liable to spontaneous combustion.

The succession of outbursts which I have now described as occurring at Nook pit is, so far as my experience extends, unparalleled. They number 26 without including those of which no particular account was taken, and they have in eight years been attended with the loss of six lives, besides narrow escapes.

They are enough to startle even persons accustomed to the dangers of mining. They might even suggest to some the idea that under such perilous and comparatively uncontrollable circumstances the mine should not be worked.

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Danger, however, cannot be altogether eliminated from mining. The aim of the Mining Engineer should be to minimise it. Had panic prevailed, when I came to North and East Lancashire as Her Majesty's Inspector of Mines, now a long time ago, many mines might have been stopped. The fatal explosions of firedamp in this part of my district then averaged ten annually, and the deaths from those explosions 36 annually; whilst when I retired from the Inspection, January 1st, 1892, the annual average, during the previous five years, was not quite one fatal explosion, nor one death; the actual average being only three-fifths of an explosion and four-fifths of a life lost, and the diminution was effected concurrently with a greatly augmented number of miners employed.

Therefore, what the improved skill and care of mining engineers did in diminishing explosions, let us hope it will do with the new difficulties of these special outbursts, and that the mineral wealth of this seam may continue available to the country with the least possible sacrifice of life.

Possibly some of the members of this Society may be able to suggest other precautions than those now being taken. In doing so the combination of causes should be considered:—

The outbursts did not begin until the workings were nearly 500 yards below the surface. Therefore depth is a factor. But it is not the only one. There are also the pressure of the firedamp, the pressure of other gas from spontaneous combustion, the expansion by heat, all acting upon the mining coal which does not possess ordinary tenacity; and also that the outbursts occur in both wide and narrow work, with drivings in every direction, with quick driving, and on resumption after intermissions of

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work, and with and without boreholes in advance. Seams of coal are being worked in the same township at 1,000 yards in depth without being subject to such outbursts; but not with the soft slippery faced sulphurous mining bed as at Nook. The problem therefore is, how to manage with this peculiar bed, and under the special circumstances.

Mr. HALL said: I have very great pleasure in moving a vote of thanks to the author of the paper. I shall be expressing everybody's views when I say how thankful we are to Mr. Dickinson for bringing this subject before us. He has given us a graphic and interesting account of a most extraordinary phenomenon, and I have no doubt the paper will give rise to a very interesting and important discussion.

Mr. SAINT seconded the motion, which was passed unanimously.

Mr. MILLS, referring to the borings, said he thought if the coal was all got on the dip—all down brow—in place of on the rise, the borings would have some effect in liberating the gas.

The CHAIRMAN asked if there was not a bed of hard rock underneath the hard coal, nine to twelve inches in thickness.

Mr. DICKINSON said there was.

The CHAIRMAN: Has it been noticed, after any of these outbursts, whether the coal itself—that is, the hard coal—has been fractured or lifted, and whether that bed of rock has been fractured?

Mr. DICKINSON: The hard coal is; I do not know about the rock. As to working the coal on the dip, I think I

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have explained sufficiently in the paper that it is worked in descending ranges, in what would be in strict conformity with the Belgian and French law—that is, that the air shall go down to the lowest point, and rise upwards; and several of these outbursts have taken place actually in driving down to the dip. The first fatal accident was where they were driving the brow down; but that seems to be scarcely the remedy that is wanted.

Mr. GERRARD (H.M. Inspector of Mines): I have listened with the greatest interest to Mr. Dickinson's paper; and I should like, if the opportunity had been a fitting one, to have asked the author a whole series of questions. Having made a close personal investigation into the last four outbursts, I should have been glad to have heard Mr. Dickinson's views, based upon his long experience, as to their cause. As far as I can gather, he has only adopted Mr. Higson's chemical theory: that is, that the soft coal contains much iron pyrites, and this substance having such an avidity for oxygen, great heat has been developed by contact with atmospheric air, and the natural expansion resulting from this has given rise to these discharges. I do not know whether Mr. Dickinson meant to convey that to his mind that was, I will not say the sole, but the predominant cause. That is one of the questions I would like to have asked.

Mr. DICKINSON: I think the paper explains that fully. The cause which I put first was the weight of the superincumbent strata. I said that it did not take place until a depth of 500 yards had been reached; therefore weight was a factor, and I put that first of all.

Mr. GERRARD: I am sure Mr. Dickinson will forgive my question. It has brought out a point in his paper which I had overlooked.

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Mr. Dickinson: It is twice repeated in the paper.

Mr. Gerrard: Mr. Dickinson's view, then, is that the chief agent is the superincumbent pressure. The chemical theory I asked about, because I had not seen a particle of evidence to support it; and if there was the great heat which is presupposed, one would expect to have found some evidence of it. After the last outburst I was down the mine within six hours of the occurrence, and I could not detect the smallest evidence of heat; and I submit that that expansion, of which the outburst undoubtedly was the result, did not follow upon chemical action evolving great heat. With regard to the borings, I should have liked to have asked Mr. Dickinson whether these, prior to 1892, were systematic or merely spasmodic. Why I ask that is this—that boring has been very intermittent within the last 15 months. There have been four outbursts, two fatal, in connection with one only was there boring, that being one hole 2½ inches diameter, 6¼ feet in advance, the greater area of the outburst was on the lower side of the hole. It has not been at all systematic, and that is one reason, to my mind, why it has failed, because the general experience in mining is that boring does let out gas just as it lets out water. The law requires that where irruptions of water are apprehended bore holes shall be driven in advance. In like manner, where gas has accumulated and bore-holes have been systematically made, the gas has been liberated. That has been proved over and over again.

Mr. Dickinson: I said that in the paper very distinctly; under ordinary circumstances it is so.

Mr. Gerrard: The application to Broad Oak Colliery would be whether the boring has been systematic or intermittent. I venture to suggest that there is a wide difference

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between systematic and intermittent boring; and with regard to the failures that have taken place, the only failure into which I have examined has been in connection with the latest outburst. The facts of this were interesting. The miner, who was in his working place when it occurred, was twice knocked down in his efforts to escape, suggesting that there was a double outburst. The man was quite clear about it. The first discharge, he said, came from the lower side, and when one examined the condition of the place it was not difficult to understand why this higher side should have come away, bringing the borehole with it. Why the borehole failed to let off the gas is another matter. That may be explained in connection with the difficulty found in making these boreholes. When a mine is "wick" or lively in motion, they have a difficulty in getting the boreholes in. Any movement would very quickly make up the hole, so that it would not operate to let off the gas, the greater pressure of the gas having been on the lower side; so that although in this case there was a hole in advance it played a very small part in connection with this area of outburst, and does not, to my mind, condemn boring. The fact of that hole having failed does not, I repeat, condemn boring. That is the only case where a hole failed to give warning of an approaching outburst. In another case that was attended, I believe, by a fatality, but of which I have no knowledge other than hearsay, there was doubt whether the hole was in or not; and I believe the people connected with the colliery themselves doubt whether it was in. I have alluded to two cases of apparent failure of the boring; I cannot enter into others, but from these two I say it is not conclusive, to my mind, that boring failed at the Broad Oak Colliery. Reverting to the cause of the outbursts, whatever weight may be attached to the chemical theory, I think there can be no doubt that the superincumbent pressure

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plays an important part. The outbursts do not occur at all until a certain depth is attained, and they seem to have increased as the cover has increased. Bearing that in mind, let us consider the nature of the "minings." The stratum is chiefly "soft" coal, extremely soft. (Mr. Ramsden, the manager of the mine, at Mr. Gerrard's request, produced some samples of this.) If you have a superincumbent mass of 600 or 640 yards, and a soft bed of that description, 16 to 20 inches thick, you naturally expect some result: then if you have—as you always have, in connection with these outbursts—discharges of large volumes of gas there you have another element. The soft coal is so extremely friable that you can crush it to powder with your fingers. This, and the fact of the "minings" within the area of outburst being almost entirely coal, explains to some extent how it contains so large an amount of gas. You have here an area which contains a larger amount of gas than the neighbouring area; and it is surrounded more or less by dense fireclay. That may be said to represent a bladder—that is the soft coal, filled with firedamp—and if nothing extraordinary were to take place in the course of working the gas would drain away.

Mr. Dickinson: I am told that the whole of the No. 5 South Level was bored regularly by their own day-wagemen and not by the colliers. Every driving was bored in No. 5 South Level, where great outbursts took place.

Mr. Gerrard: One thing I wanted to point out, namely, that in some of the coal—that which is called hard coal—there are regular cleets or joints in the seam, and these, as you will see by the diagram, working in a northerly direction as the mine was opened would let out the gas; but working in the opposite, or southerly direction, these joints

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do not let it out. There is no opportunity for the gas to escape. There is a marked difference in the number of outbursts on the north side; in fact, I believe only five or six have occurred, whereas on the south side there have been a large number; and it is certainly a fact that joints or cleets in the seam on one side allow the gas to escape, whilst on the other side there is not that opportunity. I confess I was at first very much puzzled with these occurrences. I have visited the mine a number of times, and have endeavoured to get at the facts connected with these outbursts. It is a fact that, accompanying some of the discharges, there has been subsidence or settling of the roof. Now, if you have a bladder distended with air, a sudden blow would have more effect upon it than a weight merely resting upon it. I have not worked out the theory, but I would submit to this meeting of practical engineers whether it is not possible for a settling to take place from the exhaustion of the coal, which acting suddenly like a blow upon the soft coal is the immediate cause of the outburst? I have, I say, not worked it out conclusively, but I would like practical engineers to consider that suggestion.

Mr. Dickinson: When the first fatal outburst took place, and burst up the brow, there was no wide work near it, it was all narrow work, as shown on the Plan.

Mr. Gerrard: I stated that this had occurred in 5 ft. wide places; but that fact does not prevent the superincumbent pressure, it does not prevent the subsidence. It would not be so extensive as in a wide place; but we all know that there are subsidences even in narrow places sometimes very difficult to deal with. But the difficulty in my mind is this, a mere ordinary subsidence, or settling of the roof would not be sufficient. It requires something in the nature of a blow, and my difficulty is, whether a blow would be adminis-

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tered. When the last outburst took place there was no crack in the floor; the coal under the minings sounded hollow, showing that pressure had operated upon the sides; and the coal had lifted, evidently there had been subsidence. Similar outbursts had occurred, as Mr. Dickinson stated, in South Wales; Mr. Cadman, the Inspector for that district who inspected the fatal one on 11th November, 1880, found that the coal within the area of outburst was extremely soft. The occurrence was sudden, there was no warning, and a large volume of gas was liberated. About 40 tons of small coal were thrown out. In Belgium there have been a large number of these outbursts, involving great loss of life. From 1847 to the present time there have been 56 lives lost from suffocation from fire damp and the soft coal from those outbursts, in number there have been 65 outbursts, 40 of them involving the loss of 56 lives, in addition to those, 8 brought about explosions in which 213 lives were lost, 17 were non-fatal. In the Transactions of the Midland Institute of Mining Engineers for October, 1883, Mr. T. W. Mitchell's translation of a paper by the Royal Chief Engineer at Mons, in which he described exhaustively the outbursts that have occurred since 1847, and he deals with the preventive remedies, and speaks very strongly in favour of bore holes in advance. The danger to life alone, ought to induce mining engineers to give this subject their most serious consideration, with a view to the adoption of adequate precautions.

Mr. Dickinson: Will you tell me of any additional precautions that now occur to you?

Mr. Gerrard: One naturally feels diffident, having only had recent connection with the district, in giving expression to one's views. I believe that borings should be systematically carried out in advance of all opening out

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places, and that the system of working should be such as would be most likely to permit the gas to escape, for without the gas the superincumbent pressure would not produce dangerous results. It is the gas coupled with the pressure that leads to these disasters. The borehole should be wide enough to let out the gas—not a mere perforation. I think the proprietor of the colliery is trying to carry out these, and I am watching the result.

The CHAIRMAN: I am sure you will all agree that this subject is of far too great importance to be discussed fully this afternoon. At the same time there may be some gentlemen who have come prepared to address us, and we shall be glad to have the benefit of their experience.

Miss MAIDEN (who was present by invitation) said that on the No. 5 South side, referred to by Mr. Gerrard, and shown on a tracing in Mr. Gerrard's possession, the boring was systematically carried on, and the borehole continually kept in advance from 12 to 17 feet.

Mr. GERRARD: What was its diameter?

Miss MAIDEN: Nearly four inches. Frequently the holes were much wider—sometimes so wide as to admit a safety lamp.

Mr. GERRARD: The diameter of the hole I saw was 2½ inches. On the No. 5 South Level there were no fatalities, I believe.

Mr. RAMSDEN, the manager of the colliery, said it was the fireman's duty now to keep the boring in advance of the work. He (Mr. Ramsden) visited the place daily, and saw that this was done. This morning, at 11 o'clock, the man was seven feet in with the bore when raps

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were heard. The work was stopped, and its resumption was followed by a succession of raps. There were fourteen of them, like guns going off. The fireman was in the act of trying for gas when he heard a peculiar noise, or grunt, and the lamp was filled with gas in an instant. Immediately the lamp was withdrawn the light fell to its proper size, and on trying afterwards no gas could be found. In connection with the outbursts masses of iron pyrites were thrown out; in one case he (Mr. Ramsden) found a large ball, weighing 28½lbs. There was a great quantity of this substance in the coal—both the hard and the soft coal.

Mr. De Rance said: One remark Mr. Gerrard made struck me, as not in accord with the information brought before us, or with my own experience. He spoke against the chemical theory because there was no heat six hours after one of the outbursts. Well, we learn from Mr. Dickinson's very clear paper—one of the most luminous that it has ever been my good fortune to listen to—that twenty minutes after one of these accidents the ventilation was restored and the gas went away. It is evident that any heat arising from local causes would also be cleared away. As to iron pyrites, I have myself seen in the cliffs of Lyme Regis a whole cliff for some hundreds of feet vertical, burning, after a drought of long duration; and that corresponds with the remark of Mr. Dickinson that when the material is dry, it has a greater tendency to fire than when moist. That tendency has also been observed at Kimmeridge, after a long period of drought the cliffs fire. The experiments carried on by the Underground Temperature Committee of the British Association have clearly shown the enormous amount of heat due to the decomposition of iron-pyrites. In a lead mine at Prestatyn the temperature registered by a Negretti and Zambra's thermometer was very much greater where there was a large quantity of iron pyrites, than at a much greater depth where there was none.

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That pressure is not the primary cause of these outbursts Mr. Dickinson has clearly shown. We have deeper mines than these, one at Ashton, with similar conditions, bar one, where such things do not happen. The manager of the colliery under consideration has, in the few remarks he has given us, supplied the key. He tells us that a cracking was heard, and that when this had ceased and the danger was considered passed, they went and found a great nodule of iron-pyrites. You have inflammable gas over large districts, but by the skill of mining engineers you are able to deal with it; but here you have also these great masses of iron pyrites which, in contact with atmospheric air decompose and become hot, and in my opinion the more you bore in this colliery the more of these accidents will of necessity occur.

Mr. WILD: My impression is that the real cause of these outbursts has scarcely been touched yet, for this reason. The mining coal is known to be weakly coherent, and the pressure of gas, which will blow off even large lumps of strong hard coal, can act upon this soft friable coal very readily. The superincumbent pressure is so great that it will flake off rapidly. I have seen in the Peacock mine, where there was no pyrites, men forced to stop work because of the rapid discharges of coal from the cutting face. We sank down in 1885 at Bardsley to the Royley seam, the next opening to Broadoak, where it was tapped at 700 yards deep. We found the bottom coal 2 ft. thick, and the soft coal 6 inches. The latter being thin, and showing no sign of a blow out. At Broadoak the thickness of the soft coal may have had some influence: it would weaken the resistance of that coal. We cut about 40 yards in the Royley mine, at 700 yards deep, and mined in the bottom coal only. That allowed a gap or gape to exist under the soft coal. Whether that had any effect in preventing an outburst I cannot say,

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but what is considered the same seam in the neighbourhood of Burnley is very fiery and will throw off blocks three or four inches square. I think we hardly need entertain the chemical theory, because it is evident if the gas is there, with a great superincumbent pressure upon it, and the weakly-coherent nature of the soft coal, enough circumstances exist to burst it off, and very rapidly, too.

Mr. GRUNDY promised to discuss the chemical theory with some practical chemists, and state the result at a future meeting.

On the suggestion of several members, the further discussion of the subject was adjourned.

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NOTICE TO MEMBERS.

Members in arrear with their subscriptions, will much oblige the Treasurer and facilitate the work of the Society, if they will forward, without delay, the amount due, to the Society's collectors :—Messrs. MARSHALL, GIBBON & Co., Accountants, Barton Arcade, Manchester.

May, 1893.

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JUL 13 1893

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XXII. SESSION 1892-93.

An EXTRA MEETING of the Members was held in the Literary and Philosophical Society's Rooms, 36, George Street, on Tuesday, the 2nd May, for the purpose of hearing the results of the recent boring in search of coal near Northwich.

The Vice-President, Mr. WILLIAM SAINT, H.M.I.M., in the Chair.

The Honorary Secretary, Mr. STIRRUP, mentioned the receipt of a circular from the University of Adelaide announcing the next meeting of the Australian Association for the Advancement of Science, commencing on September 25th, 1893, and inviting the attendance of members of English learned societies.

The HONORARY SECRETARY also exhibited fragments of some large concretions found in the roof of the Doe Seam at Fogg's Colliery, near Bolton, belonging to Messrs. Knowles.

These concretions are often of large size, weighing one to two cwt., nodular in shape, composed of hard clay, and which seem to be confined to one portion of the mine only.

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When broken open, the centre is found to be occupied with beautiful crystallizations of lime, white often tinged with pink or rose, the whole presenting a septarian character.

Mr. Dickinson said: Some fine nodules lie over the Doe Mine, and sometimes contain beautiful fossils, but I do not see any in these.

Mr. Stirrup: We had a number of them broken up, but did not find any fossils.

NEW MEMBERS.

The following were balloted for and duly elected Ordinary Members of the Society:—

Peter Thompson, Chamber Colliery Company, Hollinwood, Oldham.

E. L. Matthews, Mechanical Engineer and Artesian Well Borer, Nutsford Vale House, Longsight.

THE DRIFT SANDS AT SANDBACH.

Mr. De Rance said: The section of Drift Sand at Sandbach, to which I called the attention of the members at the last meeting, is still open, and any members who have not been to see it have still the opportunity of seeing a very remarkable section. At the present time it is even better shown than when I spoke here last. There is a series of what would be called in mining step faults, and the bed faulted is to all intents and purposes a coal seam, some fragments of the drifted coal being 8 or 9 inches in diameter.

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RESULTS OF THE SALT UNION BORING AT MARSTON, NEAR NORTHWICH.*

By Mr. C. E. De Rance, Assoc.Inst.C.E., F.G.S., F.R.G.S., F.R.Met.Soc., of the Geological Survey of England and Wales.

On the 18th March, 1890, I reported to the Salt Union, Limited, as follows:—

I think your Board has been well advised, in their project of sinking a deep bore-hole for coal and other minerals. The structure of the Cheshire Salt District is well illustrated by the series of longitudinal geological sections accompanying the Report of the Royal Coal Commission†; these are drawn on a true scale of one inch to the mile; they are founded on, and reduced from, the Horizontal Sections published by the Geological Survey of England and Wales, but unlike those sections, which terminate at 1,000 feet below the sea-level, the Coal Commission Sections were continued by Sir Andrew Ramsay to a depth of 5,000 feet and more.

Studying these sections and the Geological Map published on the same scale, it will be noticed that the Keuper Marls, in which the Rock Salt and Brine occur, lie in a long trough or basin, underlaid by the different New Red Sandstones, the Coal Measures, forming the rim of the basin. Through the effect of faults, causing dislocations of the strata, the rim of the basin is not continuous, and the Coal Measures are broken up into the Manchester, South Lancashire, Parkgate, Flintshire, Denbighshire, Shrewsbury, Clee Hills, Coalbrook Dale, North Staffordshire, and Cheshire Coalfields. The severance of these is more apparent than

* Communicated with the permission of the Salt Union, Limited, and embodying my Reports to them.

† Sections to explain Evidence Committee D, page D 51 to D 76. London, 1871.

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real, through the intervening tracts being concealed by the New Red Rocks and in the north-eastern portion of the area, by the intervening Permian Strata. Over a small portion of the area, the separation of the coalfields is complete, the intermediate portions having been removed by the natural processes of denudation, before the deposition of the Red Rocks which overlie strata older than the Coal Measures, just as the early chapters of a book overlie the concluding portion when the intervening portion has been removed by accident or design.*

The position of these areas of pre-coal-measure rocks have in some measure been already studied, and the results given in the Sections already alluded to, and therefore it is satisfactory to find that the Coal Measures are indicated, as probably present at Marston, near Northwich, at a depth of about 3,000 feet, thinning towards the north-east to 2,300 feet. The nature and probable dip of the underlying coal seams is not indicated, but further South, in the Alsager and Lawton District, the North Staffordshire coals are represented steadily dipping under the Marl basin, with the New Red Sandstone intervening.

The sequence of the Red Rocks of Cheshire is as follows, in descending order:—

	Thickness (Estimated in 1890). Feet.
Keuper.	
Keuper Marls, with Rock Salt	1,000
Keuper Sandstone	450
Bunter.	
Upper Mottled Sandstone	400
Pebble Beds	800
Lower Mottled Sandstone	100
	2,750

* Professor Hull, F.R.S., was the first to point out this concealed anticlinal axis of Lower Carboniferous Rocks, crossing the plain of Cheshire. *Q. J. G. S.*, 1869.

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The thickness of the Keuper Marls is given by Sir Andrew Ramsay at Nantwich as nearly 2,000 feet, but in 1890 I believed this to be in excess of the actual thickness of the bed at Marston. In this relation I gave the following sections:—

MALKINS BANK, CHESHIRE.

	Feet.
Marls (brine)	471

WINSFORD.

Meadow Bank Rock Pit, No. 1.

Depth.		Surface Level, 88·23 + O.D.	Ft.	In.	Level O.D.*
6	0	Drift, sand, and clay.....	6	0	
27	0	Variegated marls	21	0	
191	0	Marls, with hard bands	164	0	
194	0	Marls with brown granular gypsum, locally called "hornbeams"	3	0	
196	0	Hard marlstone, locally "flag" ..	2	0	– 107·77
319	6	*Rock Salt* in three beds, with two marl partings of 3 feet each. ..	123	6	– 231·27
355	6	Variegated marls, traces of salt..	36	0	267·27
475	6	*Lower Rock Salt*.....	121	0	– 387·37
		Boring of 1843:—			
489	6	Marlstone, cubes of salt	14	0	
490	6	*Rock Salt*.....	0	6	
491	6	Blue marlstone, some *rock salt* ..	1	6	
		Ditto, well bedded layers	1	0	
		Brown marlstone, few lumps of *rock salt*	13	0	
508	6	*Rock Salt*, pure	3	0	
		Brown marlstone, pieces of *rock salt*	12	0	
		Rock Salt, with marlstone	5	0	
		Brown and blue marlstone, with *rock salt*	7	0	
541	6	Ditto, ditto, with traces of *rock salt*	9	0	– 453·27

* The sign + before a figure indicates level above Ordnance Datum; sign — below the same.

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Fleetwood.

		British Alkali Union Lim.—			
		No. 22 Boring at Breckells ..			+ 20·0
509	0	Drift, and Keuper marls.....	509	0	−409·0
646	0	*Rock Salt*, one bed	137	0	−626·0
		Ditto, No. 24 Boring.....			+ 52·0
		Glacial drift	180	0	−125·0
315	0	Keuper marls	135	0	−263·0
828	0	*Rock Salt*.....	513	0	−776·0
865	0	Keuper marls.....	37	0	−813·0

Stafford Common.

		Drift and Marls.....		217	0
		Rock Salt—Marls		78	0
770	0	Marls		475	0

Enson Moor, Stafford.

		Drift.....			789	0
		Marls.....	97	3		
		Rock Salt	0	6		
476	9	Marls..	300	3		
					398	0
		Keuper Sandstone.....			271	3
915	0	Pebble Beds			167	0

Shirleywich, Staffordshire.

		Marls	324	0
408	0	Marls, with Rock Salt	15	0
		Marls	69	0

Stoke Prior, Worcestershire.

	Feet.
Marls	306
Rock Salt and Marls	154
Marls.....	340

In all the above sections brine, or rock salt was present in the Keuper Marls, in only one was the New Red Sandstone reached, which proved 300 feet of Marls to intervene between the Salt-bearing beds and the New Red Sandstone. In

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South Staffordshire, at Stoke Prior, Worcestershire, a somewhat greater distance was penetrated without the base being reached. From the investigations I have made on behalf of the Water Committee of the Corporation of the City of Worcester, I estimate the thickness of the Keuper Marls at not more than 900 feet in this part of England.

At Gainsborough, I recommended the Local Authority to bore for water through the Keuper Marls to the New Red Sandstone; this was carried out, and a plentiful supply of water, free from organic impurity, is now supplied to this town, formerly drinking the polluted waters of the Trent. The section obtained was as follows:—

	Feet.
Keuper Marls	725
New Red Sandstone	375

In this section the boring probably commences about 75 feet below the top of the Marls, consequently the Marls here are 800 feet in thickness. At Scarle, in the same county (Lincolnshire), the thickness is only 573 feet, the section being:—

	Feet.
Drift, Rhetic, and Lias	141
Keuper Marls	573
New Red Sandstone	786
Permian Sandstone	400
Carboniferous Rocks	130
	2,030

At Alsager, in Cheshire, the Marls were also penetrated, and the New Red Sandstone yielded a good supply of water, which rose above the surface, the section being:—

	Feet.
Keuper Marls	553
New Red Sandstone	437
	990

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Whether the Alsager boring commenced below the horizon of the Rock Salt, or whether that deposit may have been there present, and subsequently dissolved out, there is no evidence to show, had it been present it would have afforded a good guide to the thickness of the unproductive Marls, intervening in Cheshire between the Rock Salt and the New Red Sandstone.

Should a boring be made, it should, in my opinion (written in 1890), commence with a diameter not less than 24 inches, and should be lined throughout with iron tubes, the greatest care being exercised to prevent the possibility of fresh water making its way into the salt-beds, whether derived from water in the Drift above, falling down the bore by gravity, or rising by artesian pressure from water-charged rocks beneath.

As regards process of boring, the advantage of getting a continuous series of "cores" by the Diamond system is hardly sufficient to counterbalance its great cost and liability to break downs, through loss of diamonds and other causes, due to unequal hardness of the rocks traversed. By the old Chinese flexible rope process, great rapidity can be obtained, though not equal to the Diamond process when at work in rocks of the same hardness, and cores can be obtained by the flexible rope process whenever required, and this would probably meet the requirements of the case, but a combination of the systems would be most advantageous, using the diamond for the hard rocks and the flexible rope for the soft.

In the borings for natural gas and petroleum in the United States, in Pennsylvania, New York, and Ohio, the bore-holes or drills, as they are there called, average 2,400 feet, and some attain a depth of more than 4,600 feet, they are carried out entirely in strata of Paleozoic age, ranging

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from the Coal Measures to the Lower Silurian. The element of success in these borings is, that the strata should be tolerably uniform and hard, and not disturbed by faults, fractures, and upheavals, which have allowed the gas and oil to escape, and that the gas and oil bearing strata should be overlaid by impervious strata. These conditions probably obtain under the greater part of the Cheshire Keuper Marl district, and it is therefore possible that such deposits may occur, but the geological horizon of the older oil-beds of the United States would be at an unattainable depth, but it is possible that the carboniferous strata may be productive as they are in the States.

In a Report dated 16th November, 1891, I stated:—There is no sequence or passage between the Triassic and Permian rocks above and the Carboniferous Rocks below, consequently on penetrating the red rocks at Marston, any part of the Carboniferous Series might be encountered from the Carboniferous Limestone up to the Upper Coal Measures. The Coal Measures consist of the Upper, or Manchester Coalfield; the Middle, or Wigan and Bolton Coalfield; and the Lower Coal Measures, or Gannister Series, with the thin coals called the Mountain Mines. Between the Upper and the Middle Coal Measures is a thick unproductive Zone, and the seams of the Lower Coal Measures would not pay to work at a great depth. Any of these might occur below the red rocks, but there is strong reason to believe that the valuable Upper, or Manchester, Coalfield would be the horizon immediately underlying the red rocks. In it is the Worsley rock, a porous sandstone, and sandstones occur sparingly in the Middle Coal Measures of the surrounding area, while the Millstone Grit beneath is largely made up of porous grits and sandstones, separated by impermeable shales, beneath these are shales and limestones, and below that the Carboniferous or Mountain Limestone.

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Extensive denudation of the Carboniferous Rocks, accompanied or preceded by extensive movements and curvatures, having taken place before the deposition of the Red Rocks, it follows they may overlie porous sandstones or grits of any portion of the Carboniferous rocks, and that any horizon may occur below the Red Rocks at Marston, though it is most probable that the Upper Coal Measures—the highest horizon—is the rock there present.

Taking these facts and probabilities into consideration, I will rapidly review the distribution of petroleum and natural gas in time and space.

1. No important yield of oil or gas occurs in any rock older than the Silurians in any part of the world.

2. The large quantities of oil and gas found in Ohio and Indiana, occur in the Trenton Limestone, a highly fossiliferous Silurian rock, gently folded in trough and ridges, the gas occurs at the crown of the arches, the oil on the slopes. Many of these rocks are so porous that they hold from one-tenth to one-eighth of their bulk of oil. Overlaid by impermeable material the porous horizon when drilled to, yields the oil and gas at artesian pressure, which forces it up above the surface.

3. The oil and gas of Pennsylvania, New York, and Ontario in Canada, are from the Sandstones of the Devonian and Lower Carboniferous rocks, as are the great stores of oil in the North-West Territories. In Kentucky also and Tennessee, the oil occurs in the Ohio shales of Upper Devonian age, the whole of these strata in Cheshire are either absent or are at a totally inaccessible depth.

4. In Pennsylvania oil occurs in the Coal Measures, in three Sandstones, lying 165, 425, and 560 feet below the Pittsburgh Coal-bed. This seam is the lowest of the Upper

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productive Coal Measures of Washington County and Alleghany County in the State of New York. Gas does not occur above the Homewood Sandstone, which is the upper member of the Pottsville Conglomerate, a deposit on the horizon of the English Millstone Grit, and there is no good evidence of its occurrence in other parts of the world, in any strata of newer age. In the prairies of Athabasca it has been found associated with oil in the cretaceous rocks, but in the opinion of American Geologists it is really derived from the Devonian rocks lying below them.

In Germany petroleum occurs in the Keuper Beds, the horizon in which the Marston Boring just passed through. But in Germany this horizon is more fossiliferous and associated with plant beds (Letten-Kohl) that are absent in this country, and I did not anticipate any chance of oil occurring on this horizon.

5. All the occurrences of oil throughout the rest of the world, are in rocks of newer age, than any occurring in Cheshire, as, for instance, in the Oolites of the Pyrenees, Savoy, and the Rhone Valley, in the Tertiaries of Italy, Galicea, Hungary, Poland, Roumania, and the Caucasus, the prolific supply of Baku occurring in porous sands, between beds of impermeable clay, of Middle Tertiary age, and the oil of Algeria and Egypt is of similar age.

6. From the impermeable covering, and the fairly undisturbed state of the rocks, the Cheshire Salt District is favourably situated for the occurrences of oil in the Coal Measures, and gas in the Millstone Grit, if the conditions resemble the same beds in the United States, but the depths at which these deposits lie are most disappointing. But it must be remembered that wells of 5,000 feet are profitable undertakings in the States.

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In my Report of the 18th of March, 1890, I stated that the thickness of the Keuper Marls was doubtful, as no boring had then penetrated it from top to bottom, I doubtfully estimated it at 1,000 feet, but pointed out that my former chief, Sir Andrew Ramsay, in his evidence before the Royal Coal Commission (of which he was himself a member), gave a section through Nantwich, showing the Keuper Marls to be, in his estimation, about 2,000 feet in thickness. Looking to the fact that at Audlem, near Nantwich, the Lias formation is seen overlying the Keuper Marls, and that consequently the whole thickness of the latter must be there present, I was of opinion that as the boring at Marston did not begin in the Upper Measures of the Marls, that this estimate would be found in "excess of the actual thickness" present.

The following is an abstract of the rocks proved:—

Depth. Ft.	In.	Strata.	Thickness. Ft.	In.		
		Drift.				
31	9	Glacial Drift	31	9		
		Keuper Marls.				
412	2	Marls with Rock Salt	382	5	1763	11
1078	10	,, ,, gypsum	664	8		
1293	9	,, ,, Sandy.....	214	11		
1469	4	"Upper Keuper Sandstone" ..	175	7		
1795	8	Marls, Sandy.....	326	4		
		Lower Keuper Sandstone.				
2022	1	Waterstones	226	5	708	6
2190	4	Frodsham Beds.....	168	3		
2504	3	Basement Beds	313	10		
		Bunter.				
2610	4	Upper Mottled Sandstone	106	2 (*)		

The great thickness of the Marls, and the presence of the Upper Keuper Sandstone, is exceedingly disappointing, the

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latter was previously unknown in Cheshire, or Lancashire, but recently I found it present in a boring at Altcar, near Liverpool, in the latter county, where 1,200 feet of Keuper Marls overlaid the Lower Keuper Sandstone, which yielded a strong artesian water supply, containing in solution chloride of potassium to the extent of a ton and a half, in the water rising naturally to the surface in 24 hours.

I am well acquainted with the Upper Keuper Sandstone in Nottinghamshire, Leicestershire, and Worcestershire, but they do not outcrop anywhere in the County of Chester. They had never been penetrated or found in borings in Cheshire or Lancashire, and their presence is an unwelcome discovery, accompanied as they are, by more than 300 feet of Sandy Marls below them.

Judging by the "outcrops" in Delamere Forest, Helsby, and Beeston Castle, and numerous borings I estimated the thickness of the Lower Keuper Waterstones at 200 feet, they have turned to be 226 feet, the Basement Beds of the Lower Keuper I estimated at 250 feet, they have, I regret to report, turned out to be nearly 314 feet pointing to the district being an area of special local depression before that which led to the formation of the rock salt, and nearly the whole of the Bunter Formation still lies below the boring. As regards the Permian Rocks* intervening between the New Red and the Coal Measures, I am of opinion, that if present, they will be found of no great thickness.

As regards the Bunter Sandstone, if the beds are normal in thickness, they will be found to be, as stated in my Report of last year, as follows:—

* The Permian fringing the Lancashire Coalfield North of the Salt District, and fringing the North Staffordshire Coalfield east of it are thin, and they are absent to the west, where the new Red lies directly on the Millstone Grit of Hope in Flintshire.

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Bunter.

	Feet.
Upper Mottled Sandstone (106 feet proved)..	400
Pebble Beds	800

Permian.

Soft Sandstone	100
	1,300

Between the Bunter Sandstones and the overlying Keuper Series, there is a marked physical break, the older series have been tilted up and eroded and worn, before the overlying Keuper beds were deposited, I therefore think it possible that the special "area of depression," which led to, first—the great development of the Keuper Sandstone and afterwards to the formation of the rock salt in the Keuper Marls, may not have been in existence before the Keuper era, and the Bunter Beds may not exceed their normal thickness, but the enormous thickness recently disclosed by the Manchester Ship Canal cuttings are not reassuring. As regards the "Lower Soft Sandstone," this was always referred to the Bunter, and was so described in my report. Subsequent researches by Mr. Brockbank, F.G.S., and myself at Manchester, and by Messrs. Gray, F.G.S., and Kendall, F.G.S., at Stockport, have clearly established that it is a part of the Permian formation. I think it is very possible it will *not* be found present at Marston, therefore Carboniferous rocks may occur in the next 1,200 feet, or at a depth of 3,810 feet from the surface, or 1,060 feet deeper than might have been expected from the facts known at the commencement of the experiment. This depth of 1,270 yards is a most serious matter, it being exceedingly doubtful that were a valuable coal seam to be at once intercepted, which is entirely a matter of chance, that looking to the pressure and high temperature, it could be worked at a profit, at the present prices of coal,

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though doubtless when coal in this country becomes scarce and prices rise, mines will be freely worked at this depth.

The greatest depth now being worked in any coal mine in the United Kingdom is Ashton Moss, Audenshaw, Manchester, where the shaft is 2,820 feet deep, and Pendleton Colliery, where it is worked at 2,770 feet; Rosebridge Colliery, Wigan, 2,418 feet; Astley Colliery, Cheshire, 2,060 feet, and the Glebe and Shelton Collieries, Staffordshire (North), 2,000 feet.

I am therefore of opinion that the abnormal thickness of the Keuper Series, has destroyed the chance of working coal at a profit, as might have been reasonably hoped, before the discoveries disclosed by the boring.

On the 20th February, 1892, I pointed out that if the bore-hole be continued to the contract depth of 3,000 feet, only 100 feet of the estimated thickness of the Pebble Bed of the Bunter and of the Permian will have been penetrated, against a minimum thickness of these formations of 900 feet, and that as regards the settlement of the nature of the underlying Coal Measures, no new facts would be disclosed by the deepening of the bore-hole below its present depth to 3,000 feet.

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SALT UNION BORING AT MARSTON, NORTHWICH.

Journal of Messrs. Vivian's Rock Boring and Exploration Company, Limited.

Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1890.
..	..	.. ..	..	..	Getting plant on to the ground and erecting the same.	9th Aug.
1	0	Soil	1	0		
3	0	Red pinnel	2	0		
5	0	Sand	2	0		
8	0	Red pinnel	3	0		
10	0	Red clayey sand	2	0	Drift, 31ft. 9in. ..	16th Aug.
23	0	Red pinnel with cobbles....	13	0		
23	9	Bound gravel	0	9		
26	9	Pinnel with small beds of.. sand.	3	0		
31	9	Clayey marl..	5	0		
38	9	Red and blue marl	7	0		
73	6	Soft red and blue marl ..	34	9	.. ..	23rd Aug.
78	0	Soft blue marl..	4	6		
84	0	Soft red and blue marl ..	6	0	Hole in good order.	
96	6	Soft red and blue marl with gypsum.	12	6	Putting in 15½in. lining tubes, &c.	30th Aug.
96	6	.. ..	..	..	Putting in 13½in. tubes, completing the erection of machinery, and putting up.	6th Sept.
124	0	Red and blue marl with gypsum, rock head.	27	6	Lined hole and commenced boring with machine; hole in good order.	13th Sept.
129	0	Rock salt	5	0	.. ..	20th Sept.
214	6	Rock salt	85	6		
218	0	Red marl mixed with salt..	3	6		
220	0	Red marl	2	6		
226	6	Red and blue marl	6	0		
233	0	Red marl	6	6		
239	2	Red and blue marl	6	2		
242	5	Red marl	3	3		
263	0	Rock salt	20	7		
334	2	Rock salt	71	2	Reboring hole	27th Sept.
334	8	.. ..	..	..	Reboring hole to get 11in. tubes down.	4th Oct.
334	8	.. ..	..	..	Reboring hole to bottom.	11th Oct.
334	8	.. ..	..	..	Completed reboring hole; put in 11¾in. tubes on to bottom; preparing to bore.	18th Oct.

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Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1890.
334	8	Hard blue marl	0	6	.. ..	25th Oct.
339	3	Hard red marl	4	7		
345	9	Red and blue marl mixed with salt.	6	6		
350	7	Rock salt with blue marl. ..	4	10		
354	9	Hard blue and red marl with veins of gypsum.	4	0		
356	6	Hard red marl	1	9		
363	0	Red marl	6	6	.. ..	1st Nov.
363	6	Red and blue marl	0	6		
364	10	Red and blue marl mixed with salt.	1	4		
370	0	Salt..	5	2		
371	4	Red and blue marl mixed with salt.	1	4		
377	0	Red marl mixed with salt...	5	8		
378	2	Blue marl mixed with salt..	1	2		
390	8	Salt..	12	6		
399	8	Hard red marl mixed with salt.	9	0		
414	2	Red and blue marl mixed with salt.	14	6		
438	8	Hard red and blue marl. ..	24	6		
440	8	Blue marl	2	0		
454	8	Red and blue marl	14	0		
459	11	Blue marl	5	3		
464	5	Red and blue marl with gypsum.	4	6		
474	8	Blue marl	10	3		
476	6	Blue marl	1	10	.. ..	8th Nov.
483	6	Red marl	7	0		
490	6	Red and blue marl with gypsum.	7	0		
495	2	Blue marl	4	8		
507	7	Red and blue marl with gypsum.	12	5		
509	7	Red and blue marl	2	0		
526	7	Red marl with gypsum. ..	17	0		
528	2	Red and blue marl	1	7		
570	9	Red and blue marl with gypsum.	42	7		
584	2	Red and blue marl with gypsum.	13	5	.. ..	15th Nov.
589	2	Red and blue marl with gypsum.	5	0		
596	8	Blue marl with gypsum. ..	7	6		
615	11	Red and blue marl with gypsum.	19	3		
622	4	Blue marl with gypsum. ..	6	5		
629	10	Red and blue marl with gypsum.	7	6		
633	4	Red marl with gypsum. ..	3	6		
652	10	Red and blue marl with gypsum.	19	6		

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Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1890.
658	10	Blue marl	6	0		
684	2	Red and blue marl with gypsum.	25	4		
688	8	Red and blue striped marl with gypsum.	4	6	.. ..	22nd Nov.
694	8	Red marl with gypsum. ..	6	0		
710	2	Red and blue marl with gypsum.	15	6		
710	2	.. ..	..	..	Lining hole with 10¼ tubes.	29th Nov.
710	2	.. ..	..	..	Preparing lining tubes for next gauge.	6th Dec.
728	7	Red and blue marl with gypsum.	18	5	.. ..	13th Dec.
731	9	Red and blue marl with gypsum.	3	2	.. ..	20th Dec.
770	10	Red and blue marl with gypsum.	39	1		
777	6	Blue marl with gypsum. ..	6	8		
790	6	Red and blue marl with gypsum.	13	0		
797	0	Red marl with gypsum. ..	6	6		
805	8	Blue marl with gypsum. ..	8	8		
809	11	Red and blue marl with gypsum.	4	3		
818	11	.. ..	..	..	Trying to recover jammed cone tube, &c.	27th Dec.
						1891.
818	11	.. ..	..	..	Drawn out jammed tube, and preparing to line tube.	3rd Jan.
818	11	.. ..	..	..	Getting plant on ground to draw out jammed tubes, &c., from hole.	10th Jan.
818	11	.. ..	..	..	Have not yet been able to clear hole of jam.	17th Jan.
818	11	.. ..	..	..	Enlarging hole to clear jam.	24th Jan.
818	11	.. ..	..	..	Reboring hole to clear jam in hole.	31st Jan.
818	11	.. ..	..	..	Have not yet been successful in clearing hole of jammed tools.	7th Feb.
818	11	.. ..	..	..	Have not yet recovered the lower jammed tube.	14th Feb.
818	11	.. ..	..	..	Reboring hole over jammed tube.	21st Feb.
..	..	.. ..	..	..	Have not yet succeeded in getting out core tube, &c., jammed in hole.	28th Feb.

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Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1891.
818	11	.. ..	..	..	Got out the core tube but left cutter in hole yet.	7th Mar.
818	11	.. ..	..	..	Got out jammed tubes, &c.; rebored hole to bottom. Putting in lining tubes.	14th Mar.
818	11	.. ..	..	..	Cutting away bottom of shoe piece of tubes which is much damaged and will not allow lining to pass through.	21st Mar.
818	11	.. ..	..	..	Cutting through shoe piece with steel cutter.	28th Mar.
818	11	.. ..	..	..	Tubes are now cut and opened at bottom, so that crown passes freely. Machines will be at work boring this coming week after clearing hole.	4th April.
818	11	Red and blue marl with veins of gypsum.	9	0	Reported not drawn the 20th December, 1891.	11th Apl.
841	8	Red and blue marl with veins of gypsum.	22	9		
856	1	Red marl with veins of gypsum.	15	5	Have trouble to get core broken off.	
884	1	Red marl with gypsum ..	28	0	.. ..	18th Apl.
907	1	Red and blue marl with gypsum.	23	0	(Specimen at 905, C.E.R.)	
913	11	Red sandy marl with gypsum.	6	10		
916	11	Red marl with gypsum.	3	0		
926	0	Red and blue marl with gypsum.	9	1		
930	0	Red and blue marl with gypsum.	4	0	.. ..	25th Apl.
932	6	Red marl with gypsum ..	2	6		
937	0	Red and blue marl with gypsum.	4	6	Reported not drawn on the 18th inst.	
947	0	Red and blue marl with gypsum.	10	0		
952	3	Red marl	5	3		
956	1	Red marl with gypsum ..	3	10		
990	0	Red and blue marl with gypsum.	33	11		
1028	2	Red aud blue marl with gypsum.	38	2	.. ..	2nd May.

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Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1891.
1046	3	Red and blue sandy marl with gypsum.	18	1		
1071	1	Red and blue marl with gypsum.	24	10		
1074	1	Blue marl with gypsum ..	3	0		
1078	10	Red and blue sandy marl with gypsum.	4	9	.. ..	9th May.
1103	9	Red and blue sandy marl with gypsum.	24	11		
1111	6	Red and blue marl with gypsum.	7	9	.. ..	16th May.
1149	0	Red and blue marl with gypsum.	37	6		
1154	0	Red marl with gypsum ..	5	0		
1154	6	Very hard sandy marl with gypsum.	0	6		
1157	1	Very hard red sandy marl...	2	7	.. ..	23rd May.
1178	6	Blue and red marl with gypsum.	21	5		
1205	6	Red and blue sandy marl with gypsum.	27	0		
1213	0	Very strong red sandy marl.	7	6		
1215	6	Red sandy marl very strong.	2	6	.. ..	30th May.
1234	7	Red and blue sandy marl with gypsum.	19	1		
1240	1	Red sandy marl with gypsum.	5	6		
1244	1	Red and blue marl with gypsum.	4	0		
1248	1	Blue marl with gypsum ..	4	0		
1255	7	Red and blue marl with gypsum.	7	6		
1269	7	Red sandy marl with gypsum.	14	0	(Specimen 1261, C.E.R.)	
1277	9	Blue marl with gypsum ..	8	2	Ground bores slowly.	
1293	9	Red marl with gypsum ..	16	0	.. ..	6th June.
1321	3	Red sandstone with red marl and gypsum.	27	6		
1343	9	Red sandstone with red marl.	22	6		
1356	9	Red sandstone with red marl.	13	0	(Specimen at 1376, C.E.R.)	13th June.
1383	3	Red sandstone with red marl.	26	6		
1412	6	Red sandstone with red marl and gypsum.	29	3		
1415	0	Red sandstone with red marl.	2	6		
1416	0	Grey sandstone	1	0		
1433	6	Red sandstone with red marl and gypsum.	17	6		
1436	0	Red sandstone with red marl.	2	6		
1453	6	Red and grey sandstone with red marl.	17	6		
1460	0	Red sandstone with red marl.	6	6		
1464	0	Red sandstone	4	0		

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Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1891.
1467	4	Grey sandstone	3	4		
1469	4	Red sandstone with red marl.	2	0		
1492	4	Red and blue sandy marl with gypsum.	23	0	(Specimen 1488, C.E.R.)	20th June.
1514	10	Red sandy marl with gypsum.	22	6	.. ..	27th June.
1527	4	Red sandy marl with gypsum.	12	6	.. ..	4th July.
1533	9	Red sandy marl with gypsum.	6	5		
1538	0	Red sandy marl with gypsum.	4	3		
1553	0	Red sandy marl with gypsum.	15	0		
1557	5	Red and blue marl with gypsum.	4	5	.. ..	11th July.
1612	2	Red and blue sandy marl with gypsum.	44	9		
1625	2	Red sandy marl with gypsum.	23	0	.. ..	18th July.
1653	0	Red and blue sandy marl with gypsum.	27	10		
1727	8	Red and blue sandy marl with gypsum.	74	8	.. ..	25th July.
1749	9	Strong red sandy marl with gypsum.	22	1	.. ..	1st Aug.
1771	9	Strong red and blue sandy marl with gypsum.	22	0		
1795	8	Red and blue sandy marl with gypsum.	23	11		
1799	7	Red sandstone with red marl.	3	11		
1807	0	Red and blue sandstone with red marl.	8	2	.. ..	8th Aug.
1809	9	Red sandstone	2	0		
1820	7	Red and blue sandstone with red marl.	10	10		
1823	1	Red sandstone	2	6		
1829	11	Red marly sandstone ..	6	10		
1831	11	Red sandstone	2	0		
1831	11	.. ..	..	..	Delayed through cylinder of steam winch breaking.	15th Aug.
1838	6	Red sandstone	6	7	.. ..	22nd Aug.
1842	3	Red and blue sandy marl ..	3	9		
1848	3	Red sandstone	6	0		
1850	3	Red and blue sandy marl ..	2	0		
1855	0	Red sandstone	4	9		
1856	4	Red and blue marl	1	4		
1857	4	Red and blue sandy marl ..	1	0		
1859	10	Red sandstone with red marl and spots of gypsum.	2	6		
1864	10	Red and blue sandy marl ..	5	0		

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Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1891.
1870	1	Red sandstone with spots of gypsum.	5	3		
1882	7	Red sandstone with blue joints and spots of gypsum.	12	6		
1884	7	Red sandstone with red marl and blue joints.	2	0		
1886	3	Red and blue sandy marl ..	1	8		
1890	7	Red sandstone with red marl and spots of gypsum.	4	4		
1893	1	Red sandstone with red marl blue joints and spots of gypsum.	2	6		
1895	5	Red and blue sandy marl with veins of gypsum.	2	4		
1896	5	Blue sandy marl	1	0	.. ..	29th Aug.
1898	5	Red marly sandstone	2	0		
1900	11	Grey sandstone	2	6		
1918	2	Red sandstone with red and blue marl joints.	17	3		
1923	2	Red sandy marl with blue joints.	5	0		
1929	2	Red sandstone with red sandy marl joints.	6	0		
1933	4	Grey sandstone with blue marl beds.	4	2		
1936	10	Red marly sandstone with gypsum.	3	6		
1939	10	Grey sandy marl	3	0		
1941	3	Red marly sandstone	1	5		
1942	10	Grey sandy marl	1	7		
1944	4	Red marly sandstone	1	6		
1945	1	Grey sandy marl..	0	9		
1946	3	Red marly sandstone	1	2		
1947	3	Grey sandy marl..	1	0		
1948	3	Red marly sandstone	1	0		
1949	7	Red sandstone	1	4	.. ..	5th Sept.
1953	10	Red sandstone with joints of grey sandstone.	4	3		
1954	6	Grey sandstone	0	8	.. ..	
1963	11	Red and blue sandy marl ..	9	5		
1978	7	Red marly sandstone	14	8		
1981	3	Red sandstone with red marl.	2	8		
1996	10	Red and grey sandstone with red marl.	15	7		
2022	1	Red sandstone with red marl.	25	3		
2032	7	Coarse red sandstone with spots of gypsum.	10	6		
2075	3	Soft red sandstone	42	8	.. ..	12th Sept.
2085	6	Soft red sandstone	10	3	.. ..	19th Sept.
2086	7	Soft red sandstone with spots of gypsum.	1	1		

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Totol Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1891.
2109	7	Soft red sandstone	23	0		
2110	9	Soft red and grey sandstone.	1	2		
2133	3	Soft red sandstone	22	6		
2180	3	Soft red sandstone	46	11	.. ..	26th Sept.
2190	4	Soft red sandstone	10	2	.. ..	3rd Oct.
2191	10	Hard red and grey sandstone.	1	6		
2193	10	Red sandstone	2	0		
2204	7	Red sandstone with grey joints.	10	9		
2205	5	Red and blue sandy marl ..	0	10		
2217	2	Red sandstone with grey joints.	11	9		
2227	7	Red sandstone with red marl joints.	10	5		
2236	9	Red sandstone	9	2		
2239	11	Red sandstone with grey spots and marly joints.	3	2		
2248	4	Red marl with blue joints and red sandstone.	8	5	.. ..	10th Oct.
2250	10	Red sandstone	2	6		
2263	2	Coarse greyish red sandstone with spots of red marl.	12	4		
2276	0	Greyish red sandstone and red marl.	12	10		
2288	5	Greyish red sandstone with blue joints and red marl.	12	5		
2300	11	Greyish red sandstone with blue joints.	12	5		
2307	2	Greyish red sandstone ..	6	4		
2316	10	Red and grey sandstone ..	9	8	.. ..	17th Oct.
2317	10	Red sandy marl	1	0		
2322	8	Red and grey marly sandstone.	4	10		
2325	8	Red and grey sandstone ..	3	0		
2328	2	Red marly sandstone.. ..	2	6		
2330	0	Red and grey sandstone ..	1	10		
2342	9	Greyish red sandstone with red marl joints.	12	9		
2363	2	Greyish red sandstone.. ..	20	5		
2371	2	Red sandy marl with blue joints.	8	0	.. ..	24th Oct.
2373	7	Red sandstone	2	5	.. ..	
2408	10	Greyish red sandstone with blue joints and mica.	35	3		
2412	0	Red and grey sandstone ..	3	2	.. ..	31st Oct.
2412	10	Very hard red marl	0	10		
2415	3	Strong red marl	2	5	.. ..	7th Nov.
2419	3	Strong red marl	4	0		
2425	6	Red sandstone with blue joints.	6	3		
2429	7	Red sandy marl with blue spots.	4	1		
2433	7	Red sandy marl	4	0		

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Total Depth Bored.		Nature of Strata.	Thickness.		Remarks.	Date Week ending.
Ft.	In.		Ft.	In.		1891.
2440	1	Red and grey sandstone ..	6	6		
2442	8	Red sandstone	2	7		
2453	8	Red and grey sandstone ..	11	0		
2461	9	Red sandstone with spots of marl. ..	8	1		
2465	5	Red and grey sandstone with spots of marl.	3	8		
2478	5	Red and grey sandstone with red marl.	13	0	.. ..	14th Nov.
2483	7	Greyish red sandstone with spots of red marl.	5	2		
2484	3	Red marl	0	8		
2492	7	Greyish red sandstone.. ..	8	4		
2497	3	Red and grey sandstone ..	4	8		
2500	10	Red and grey sandstone with spots of red marl.	3	7	.. ..	21st Nov.
2504	2	Red and grey sandstone ..	3	4		
2510	9	Soft red sandstone	6	7		
2519	7	Red and grey sandstone ..	8	10		
2520	0	Soft red sandstone	0	5		
2520	4	Red sandy marl	0	4		
2520	10	Red sandy marl.	0	6	.. ..	28th Nov.
2522	2	Red sandy marl	1	4	Rebored hole to bottom, 7in. diam.	5th Dec.
2524	3	Red sandy marl	2	1		
2525	6	Red sandstone	1	3		
2529	10	Red sandstone with a blue sandstone joint and red marl joints.	4	4		
2531	4	Red sandstone	1	6		
2532	2	Red sandstone	0	10	Ground troublesome to bore.	12th Dec.
2532	4	Red marl	0	2		
2533	10	Red marl with grey sandstone joint.	1	6		
2535	4	Red marl	1	6		
2536	4	Red marl	1	0	Machine is boring better since brine was laid on.	19th Dec.
2539	0	Red sandstone with red marl.	2	8		
2550	3	Red sandstone	11	3		
2553	3	Red and grey sandstone ..	3	0		
2557	3	Red sandstone with grey joints.	4	0	Troubled with soft marl falling in the hole.	26th Dec.
2558	1	Red sandstone	0	10		1892.
2558	7	Red marl	0	6	Marl still falling in hole; water will not pass owing to heavy run of brine.	2nd Jan.
2572	9	Red sandstone with grey joints and spots of marl.	14	2		
2583	9	Red sandstone with grey joints and marl.	11	0	Think the run of dirt into hole is reducing, but we have to work carefully to avoid jamb.	9th Jan.
2584	1	Red sandstone	0	4		
2586	0	Red sandy marl	1	11		
2597	0	Red sandy marl with grey joints.	11	0	Hole still a little dirty, but pressure is not quite so high.	16th Jan.
2610	4	Soft red sandstone	13	4		

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Remarks.	Week ending.
	1892.
Rush of dirt into hole jammed boring tools in bottom	23rd Jan.
Have not been able to clear hole of jamb yet	30th Jan.
Recovering jammed tube from hole	6th Feb.
Recovering broken rods	13th Feb.
Recovering broken rods from hole	27th Feb.
Have not been able to recover the broken rods yet	5th Mar.
Recovering broken rods from hole	12th Mar.
Recovering broken rods from hole	19th Mar.
Recovered part of the broken rods from hole	26th Mar.
Recovering broken rods from hole	2nd Apl.
Recovering broken rods from hole	9th Apl.
Recovering broken rods from hole; holidays interfered with work	16th Apl.
Recovering rods broken in hole	23rd Apl.
Have got a large quantity of rods out this week	30th Apl.
Have not yet recovered all the broken rods	7th May.
Delayed from breaking down of machinery; have got it repaired	14th May.
Cleaning out dirt from off tops of jammed tools in hole	21st May.
Cleaning dirt off the top of core-tube, &c., jammed in hole	28th May.
Have recovered more of the broken rods from hole; only core-tube now remains.	3rd June.
Have not yet been able to draw the core-tube, &c., from hole	11th June.
Reboring hole to get over the tube, &c., jammed in bottom	18th June.
Have not yet completed the reboring of hole	25th June.
Expect now to complete enlarging of hole in a day or two..	2nd July.
Expect to be able to clear hole of jam early next week	9th July.
Have not yet been able to draw tube from bottom of hole	16th July.
Cutting away obstruction in bottom of hole with steel cutters	23rd July.
They have not been able to remove obstruction in bottom of hole	30th July.
Cutting away obstruction in hole with steel cutters	11th Aug.
Have not yet been successful in removing obstruction in hole; Mr. Vivian may, however, continue a little longer his efforts to recover his rods and crown.	17th Aug.
Cutting obstruction away with steel cutters	24th Aug.
Cutting obstruction away, &c.	1st Sept.
Reboring on to jammed tube	7th Sept.
Reboring hole over jammed tube	14th Sept.
Reboring over tools jammed in hole	21st Sept.
Reboring hole to clear jammed tools	28th Sept.
Have not yet been able to draw jammed tubes from hole	5th Oct.
Reboring over jammed tube with steel cutters	12th Oct.
Have now succeeded in removing obstruction; hole is now clear	19th Oct.

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Mr. De Rance expressed regret at the unavoidable absence of Mr. John Rigby, M.E., of the Salt Union, Limited, who had undertaken to give some notes on the engineering details of the Marston boring. Mr. Rigby had been unexpectedly summoned to London on business connected with the Weaver Trust Bill, now before Parliament. With regard to the detailed section which was exhibited in illustration of his paper, Mr. De Rance explained that he was indebted for its use to Mr. Ward, F.G.S., who had very kindly placed it temporarily at the Society's disposal, in order that a reduced copy might appear in their Transactions, if so desired.

Mr. Ward (of the Salt Union), who was invited to give the meeting some account of the boring from an engineering point of view, said he would prefer to leave all engineering details to Mr. Rigby, who would no doubt give the Society the benefit of them at a future meeting. Mr. Ward continued: I agree to a very large extent—indeed, I think, almost entirely—with Mr. De Rance with respect to this boring. During the progress of the work, I put down in a short form, an account of the strata passed through, thinking it might be useful; and I may say that we have hit upon the same divisions, and must therefore necessarily have come to the same conclusions, but I leave to Mr. De Rance the sub-division of the sandstones into their various groups. It is clear to me that the deposition of the Cheshire salt beds has been a continuous process, right to the top, and including the saliferous marls that overlie the salt. Starting just below the drift, and going to the bottom of the borehole, it appears to me to be one continuous whole, and we must not look upon the salt as something strange. It is not so. It is a marl formation, the same as all the rest, but with a good deal of salt in it; below it is marl with less salt and

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more sand in it. But, really and truly, marl is the prevailing feature from the bottom of the bore-hole to the top. Marl, either in specks or little lumps, on thin layers, occurs throughout, so that the history of the thing is one from the beginning to the end. But to me the most interesting question is—What has been the cause why, at one particular time, sand should predominate, and at another time marl, and why at another time salt should predominate without any sand at all near it, I cannot quite understand, but I think if we could read the history of these beds as we should like to read it, it would tell us a great deal of what was going on on the earth's surface at the time of this deposition. Evidently this part of Cheshire was a great salt lake—a very deep one indeed—in which marls and sands were deposited to a depth of over 2,000 feet. Into this lake there must have been rivers running, because the whole of the deposit is a river deposit, I take it. It may have been a bay—or lagoon, not the open sea—but when we get to the salt we know that this could not have been deposited in the open sea. Whatever it may have been before, it was an inland lake then. It is only when a portion of the sea gets shut off—some arm or bay of the sea—by reason of the rising of the land or deposits of sand, that you have the conditions under which salt can be deposited. There is, no doubt, a very peculiar history connected with it, but it is a history which I am by no means clear about. I cannot understand why, at particular times, there should have been marls without a trace of sand, and then, in exactly the same spot, perhaps a little lower or a little higher, marls full of sand, or these mixed in varying proportions. But the whole thing, as I said, has one continuous history. The surface drift, of course, has nothing to do with it, because the period of time between the deposit of the top marl, and the

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deposit of the drift was immensely long. What was deposited immediately above the saliferous marl, and what has become of it we do not know. Perhaps Mr. De Rance will say that limestone covered it all over, and was denuded. I should like really that we should try to find out, if we can, why in particular times there were deposited masses of gypsum. I do not think when we get to the bottom of the bore hole we met with many traces of gypsum, but in the upper marls above the salt we found considerable quantities, not so much in layers as in big lumps. Below the rock salt, where the marl become very hard, the gypsum is spread over in a thin layer, exactly the same as in the specimen which Mr. De Rance showed you. I have at home a beautiful plate of it which is quite white and almost transparent, about half an inch thick. I am sorry I did not bring it to this meeting. I would like to puzzle out, if it could be done, what happened to cause the salt to be deposited in the upper portion of the marls, when there is no trace of salt in the lower portion. The salt beds extend to about 290 feet altogether. They commence with thin veins and crystals of salt and pass into the beds coloured blue in the section. The two beds are separated by 27 feet to 30 feet of hard marl. These deposits have a most interesting history if only we could trace it out. A change took place in the land surface of the country, the drainage from which brought the sand and mud into this area. Undoubtedly there must have been subsidences and elevations going on, and if we could find out more about these it would assist us in arriving at a clearer knowledge of the conditions under which the salt was deposited. Mr. De Rance says the rock salt in various parts of the country differs materially as to the number of beds and thickness of the marl. That, I think, substantiates what I have always held, that salt has not been deposited in one immense lake,

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but in dry seasons, in a number of lagoons or salt lakes such as we find in the Steppes of Russia at the present day. That might account for a general similarity, but not for great coincidences. The chief coincidence is the bed of marl lying between the two thick beds of rock salt. This would seem to indicate that at the particular time represented by that marl bed, the climate had changed, and that dry seasons had given place to wet ones in which the conditions were not favourable to evaporation. I do not know that I need say more about the matter. It is a very interesting boring, and though not satisfactory from a financial point of view, it has taught us a good deal. The most singular thing about it, as it seems to me, is that we hit upon the very thickest part of the salt at that particular spot, and it would seem also on the very thickest part of the marls. It is curious how, from that particular spot, almost every way you go, particularly to the south, west, and east, the rock salt falls off very rapidly, and within about a mile and a quarter it terminates entirely. The north side has never been tested. We might have put a bore hole down and not have met with any of these interesting things. We found no fossils whatever. I do not think a single fossil has been detected in any of the cores brought up. It is very strange that, although water must have existed for ages in this area, and although streams were running into it through the marls and sands, we find no trace whatever of life. It is so in the salt deposits in all parts of the world. I have been struck with some rather peculiar things in connection with the beds of rock salt at Northwich. About these I may, some time, have more to say to the Society. The following are the measurements I have preserved of the boring:—

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Borehole at Marston, near Northwich, sunk for Coal.

Depth from Surface. Ft.	in.		Ft.	in.	Thickness of Material. Ft.	in.	
31	9	Soil and drift	....		31	9	
124	0	Red and blue marls (Keuper) ..	....		92	3	Salt Measures.
214	6	Upper bed of rock salt	....		90	6	
242	5	Hard marls, with salt veins ..	....		27	11	
334	2	Second or Lower bed (so called) of rock salt	....		91	9	
364	10	Hard red and blue marl with salt	290	2	30	8	
370	0	Rock salt..	....		5	2	
378	2	Hard red and blue marl with salt	....		8	2	
390	8	Rock salt..	....		12	6	
414	2	Red and blue marl with salt ...	....		23	6	
1293	9	Red and blue marl with gypsum.	....		879	7	
1469	4	Red and grey sandstone with red marl and gypsum	....		175	7	
1795	8	Red and blue sandy marl with gypsum	2196	2	326	4	
2610	4	Red and grey sandstone with red and blue marl joints and spots	....		814	8	
					2610	4	

The points which require elucidation seem to be the following:—

1. Nature of sea in which marls and salt are deposited; or, query—bay, or Mediterranean Sea, or Salt Lake.

2. Cause of shutting off of inland lake from sea at time when salt first began to form.

3. Causes of change from sandstones and marly sandstones to pure marl.

4. The whole formation, from the drift downwards one of marls, terminating finally in sandstones.

5. The salt merely salty marl, and similar to sandy marl, the salt taking the place of the sand.

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6. Does the salt indicate a drier climate, or merely the same climate acting on an inland salt lake instead of the sea?

7. Marl indicates heavy rains and floods, also sand the same.

If (Mr. Ward continued) we could carry our minds back, and get an idea of what the nature of the country was at this period—what rocks formed the surface of the land, and even where the land was, for we do not know that with certainty—it would be a great help in the elucidation of these questions. We have had maps purporting to show the surface of the land at various ages, and perhaps Mr. De Rance might construct an interesting map showing the probable land surface at the time when this great deposit of sand, salt, and marl took place.

Mr. De Rance: Our honorary member, Professor Hull, has prepared such a map, one of a series published in the proceedings of the Royal Dublin Society, and afterwards reprinted in 1882 by Mr. Stanford.

Mr. Watts said: The interest Mr. De Rance takes in the Manchester Geological Society is well known to every member of it. The fund of information which from time to time he brings before us is of deep interest, and I do not know that on any previous occasion he has brought results before us so interesting as those which he has given to-day with regard to the boring near Northwich. The great interest of the paper, at least to myself, is that it makes known the vast thickness of the salt beds in that district—no less than 513 feet. With regard to the formation of those beds, to which the last speaker alluded, the old notion was that salt was deposited as the result of evaporation. It is well known that brine when evaporated leaves a deposit of salt, and there seems to be no doubt that in the Cheshire area, lakes once

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existed which became flooded with sea water, and that this water was evaporated, and salt was deposited. This process would be repeated throughout a vast period. And it would appear from the great changes which have been described that not only has evaporation taken place from time to time, but the whole area has been, so to speak, churned up. I do not propose, however, to enter into any discussion of these questions. My present duty is to propose that the best thanks of the meeting be given to Mr. De Rance for the paper he has read this afternoon.

Mr. Joseph Dickinson: I have much pleasure in seconding the vote of thanks to Mr. De Rance for the very useful paper he has brought before us. We might also, I think, couple our thanks to Mr. Ward for the information he has added, and also to the Salt Union for so kindly placing before this body and the public generally, the valuable information obtained by means of this bore hole. The subject is one which I prefer not to discuss off-hand. I hope that in addition to the abstract section which Mr. Ward has drawn out we shall have the detailed section given in our Transactions.

Mr. De Rance: The detailed section is on the table now.

The vote of thanks was passed unanimously.

Mr. De Rance, in acknowledging the resolution, said the subject was one in which he took a deep interest himself, and it had been a great pleasure to him to bring it before the Society.

Mr. Arthur Timmins said: The section which has been described is to my mind very interesting and very valuable. It shows the greatest depths of Keuper Marls we know of in England, and I think when the borehole reached its

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greatest depth Mr. De Rance wisely suggested that it should be discontinued, because, from the information we have got since, the thickness of the Upper Mottled Sandstones, might have been a thousand feet for anything we could tell. Then there are the Pebble Beds and the Lower Mottled Sandstones, and the Permian Marls which Mr. Ward thinks follows through all these sandstone beds. Of course, the salt measures themselves are very interesting. One point I have noticed in the Northwich field is that on the Northwich side we get the salt beds intercalated less frequently with beds of marl; so much so, that a mass of 90 feet of rock salt, as it occurs there, may within a distance of seven or eight miles N.E. be split up into numerous layers of a yard in thickness, which seems to show that the flow of sediment which went to form the marl was from that direction, towards Northwich, for on that side alone have we any trace of the salt measures thinning out as Mr. De Rance has described. On the other side we find the salt beds terminate abruptly, whether by being cut off by a fault, or naturally, we cannot say. Information on that point would be very valuable. One point which struck me was the occurrence of gypsum in the lower strata; that is a thing quite new to me. I do not know what it means, or what it points to, whether it is gypsum deposited *in situ*, or whether it has travelled there, or been compressed in a new form, I cannot say. It is new to me to find gypsum so low down in the sandstones. No doubt it is disappointing to the Salt Union, after spending so much money, not to have got more information than we have. We have got a lot, but we should have liked more.

Mr. Stirrup: I think we must all regard the paper as most valuable, and although the boring has not answered the expectations of the Salt Union, still it has brought an immense amount of information to geologists, and possibly information that may be utilised hereafter. With regard to

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the marls I am altogether of Mr. Ward's opinion that we have here, as it were, a continuous series of deposits. They bear great similarity, some, of course, indicating times of greater or less deposition; others, times of erosion, and others, again, times when the lands have been moderately steady, and when the thick beds of salt were allowed to accumulate. Mr. Ward said he would like to know something with regard to how these deposits of salt had been brought about; also the gypsum—why we find it in certain places and not in others, and whether the deposition of salt indicates a dry climate.

These questions are exceedingly interesting ones. My own view is that gypsum is certainly very intimately connected with the deposition of salt, in fact a mere episode in a chain of events brought about by the physical conditions then obtaining, and that wherever you have gypsum you have the assurance that the materials for the deposition of salt were present.

This has been sufficiently proved, I think, by the results of some experiments in chemical geology made a few years ago by the late M. Dieulafait, an eminent French chemist, and also by the manufacture of salt by the natural evaporation of sea water as now carried on in the marshes of the estuary of the Rhone, in the south of France. M. Dieulafait showed that it is simply a question of the amount of evaporation to which sea water is submitted, whether you have a deposit of gypsum or salt. If ordinary sea water is diminished by evaporation of $\frac{1}{10}$ths of its primitive volume, you have gypsum deposited, and if this process is continued until another tenth of the sea water is evaporated then chloride of sodium or common salt is precipitated.

These experiments are borne out by the practice of the salt marsh workers of the Mediterranean coast, who intro-

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duce sea water into shallow pans or reservoirs, where it is allowed to evaporate by the action of the sun's heat and deposit the gypsum, when the residue of the sea water is passed into special basins, where the pure salt is deposited and collected for sale.

Applying these researches to an explanation of our Cheshire salt deposits, the case would seem to require low-lying lands subject to temporary and frequent inroads of the sea, time for evaporation of the shallow waters, and a temperature equal at least to that of Southern Europe.

As to the other interesting geological questions Mr. Ward has put, Mr. De Rance will be much better able to answer them than I am. Personally, I thank both those gentlemen for the very interesting material they have laid before us.

Mr. De Rance, in replying upon the discussion, said: I hardly know, Mr. Chairman, that I have anything to reply to, most of the remarks made by members having been more or less complimentary. The subject is a very large one, and very interesting, and I only wish Mr. Ward would apply his mind to write a paper for the Society on the points to which he has drawn our attention. Any inquiry must be interesting which seeks to reveal the physical conditions of a past period. With regard to gypsum I quite follow Mr. Stirrup's remarks about the relation of gypsum and salt as a rule, and it has been very curiously substantiated by a specimen I saw when I went to select these samples. We selected three sets, one for the Geological Museum of Manchester, one for the Museum of Practical Geology in London, and the third for the Salt Museum at Northwich. The specimen referred to—which I am glad to see on the table here—came from near the bottom of the marl, 1800 feet below the surface, and it exhibits pseudomorphous crystals of rock salt, showing that rock salt, although not discovered in this part

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of the boring, had been formed at that early period of the marl series. The crystals are small, but at the same time they are very distinct. It is not the universal rule that gypsum occurs with rock salt; we find any amount of it in the basement bed of the Gault. Then again we have evidence of its formation even in our own time. At Primrose Hill vast quantities of clay were thrown out of the railway tunnel, it is stated of this clay, that after it had been acted on by the weather, lumps of gypsum, the size of your fist, appeared on the surface, having been formed by atmospheric chemical action. Therefore it is a question whether, in certain sandy beds down below, which are soft and porous, admitting water readily, the gypsum met with is not more modern than the formation in which it is found.

A paper entitled "Further Notes on Boulders from the Coal Measures," by Mr. Mark Stirrup, was postponed to the June Meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XXII. SESSION 1892-93.

WIGAN MEETING.

THE ORDINARY MEETING of the Members was held on Friday, May 12th, 1893, in the Mining School, Wigan.

Mr. W. SAINT, H.M.I.M., Vice-President, in the Chair.

NEW MEMBER.

The following gentleman, having been duly nominated, was unanimously elected an Ordinary Member of the Society:—

Mr. VINCENT W. LAITHWAITE, Mining Engineer, Post Office Chambers, Bradshaw Gate, Bolton.

ON THE DEEPENING OF A SHAFT UNDER THE CAGES AT WIGAN JUNCTION COLLIERY.

By Mr. THOMAS GRUNDY.

In the discussion which took place on Mr. Tonge's paper, it occurred to me that an arrangement such as we had used in the sinking of a shaft under cages might perhaps be of some little interest to the Society, and the object of the paper and plans is to try to give you an idea how this was

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arranged. The shafts are situated in Abram, owned by the Wigan Junction Colliery Company, and known as the No. 3 and 4 shafts respectively. The pits had been sunk to the depth of, in the No. 3 pit, 600 yards; and in the case of No. 4 pit, to the depth of 510 yards; and to the mine known as the Wigan six feet. It is to deepening of the No. 4 shaft under the cages and the system of getting rid of the *debris* which we have for our consideration. The shaft was fitted up for winding coal and cannel from the Pemberton five feet, Bickershaw seven feet, and the Wigan four feet. It is 14 feet in diameter, and in it are worked two cages having a length of 7 feet 6 inches and width of 3 feet 5 inches, the cages are kept in position by means of eight conductors, four to each cage, and allowing a distance for clearance between the cages of 2 feet 3 inches. The rods were weighted at the ends by the ordinary cheese weights to the extent of about 50 cwt. to each rod. The cages were three-decked, two tubs in each deck, and the cages were worked to the Wigan four feet mine, the mine next above to where the shaft was already sunk to, and having a distance of 30 yards between the two seams. You have now an idea how the shaft was arranged before commencement of sinking.

It was found necessary to deepen this shaft to the depth of 120 yards further, and knowing that strata which would have to be passed through would prove troublesome, in consequence of numerous faults running across the shaft, it was found desirable to dispense with a running jiddy as it would be necessary to make a rather wide excavation and put down an arrangement of falling doors. This was done and put in position in the shaft immediately opposite to the Wigan Six Feet Mine, and a communication having been made in this mine between the No. 3 and 4 shafts, it was decided that all the debris, from the sinking and material for bricking, should pass through this mine to

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and from the surface. Arrangements being already in work in the No. 3 shaft by means of a single cage and conducting rods, whereby the material could be hooked on and sent to the surface or *vicè-versa*.

The means adopted for winding were as follows: A rope 130 yards long was secured to the coupling immediately under the detaching hook, the rope being passed through holes 8in. diameter cut through each deck of the cage, and as the rope was passed through the deck the men in charge of the work held the capping under the detaching hook till connection was made by screwed nut and pin. This was the only connection to be made or disconnected, and the time usually taken was about three minutes. The rope hanging then to the bottom where the debris was taken off, and when not in use in the day time was put on a reel on the lower side of the level. It was found that the length of the rope hanging down the pit between the two mines was rather an objection in making a quick connection, and to facilitate this a pair of clamps, with a hook at one end, were fixed on the rope about two yards underneath the cage.

These clamps served the purpose of keeping the underhanging rope up when disconnection or connection was taking place, by the hook on the end of the clamp being brought to the side of a bearer and hooked into an eye bolt fixed on the bearer. You will see, from the sketch exhibited, the position of these, and that when disconnection had taken place the rope underneath is hanging by these clamps, the upper part and capping having been lowered underneath scaffold and secured out of the way of the cage. It occurred to me to put a kind of false scaffold immediately under the conductor weight, as a safeguard in case of anything falling down the shaft or the vibration of the rods causing any of the cheese weights to come off.

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You will see from the sketch the arrangement of doors and landing for taking off the *debris* of the sinkers. The doors are connected with levers, so that both doors are opened or shut at once, and the handle for working the arrangements is so situated as to be convenient to the signalling wires, which, I may state, were in duplicate, to prevent an accident taking place in case of one of the signal wires breaking. The *debris* in the hoppet, after being taken off the rope, was afterwards run along the level some 20 yards and tipped into tubs; the tubs being taken to the No. 3 Shaft and wound in the cage.

In conclusion, I may say that as the connecting of the rope to the link under the detaching hook was important, the persons engaged to do this work were the underlooker (in charge of the mine), the back fireman, and hooker-on; and these persons had written instructions given to them to stay there after the completion of their work of connecting the rope till the engine-man had stretched all the rope off the reel, and the hoppit had been hooked on to the rope, and run down and up; this time took about five minutes. These men were then at liberty to proceed to the surface, and the men in charge signed a special report that every thing was all right.

The sinking commenced at 4 o'clock in the afternoon, was continued till 5 o'clock in the morning, and anyone entering the mines between those times did so from the No. 3 shaft.

The CHAIRMAN said he was particularly interested in hearing the description of the signalling apparatus. He thought it was a wise arrangement to have those signal wires in duplicate. It was not long ago there was an accident in a sinking shaft in the Manchester district, owing to the breakage of the signalling wire, when one man was

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killed. Shots were about to be fired, and the engine-man had given the return signal to intimate that he was "ready," when the signal wire broke between the crank lever and the engine-room on the surface. The shot-lighters matched the fuzes, and attempted to signal to be wound up, not knowing of the breakage. The engine-man, although he knew they were shot-firing, did not think it was advisable to move the hoppit without a signal. Owing to the delay in moving the hoppit, the shot-firers suspected there was something wrong with the signalling apparatus, and cut the fuzes when too late. They then tried to protect themselves by crouching in the hoppit; and when the shots fired, one of the men received severe injuries, from which he died. Had duplicate signalling wires been provided in this case, in all probability the accident would not have occurred.

Mr. Tonge moved a vote of thanks to Mr. Grundy for the trouble he had gone to in preparing the paper and in making the drawings.

Mr. Unsworth, in seconding, said he did not know whether the circumstances with which Mr. Grundy had had to do were the same that Mr. Tonge had to deal with in his sinking at Hulton, but he (Mr. Unsworth) came across an instance at the Wigan Coal and Iron Company, some years ago, in sinking from the bottom of the shaft, in which the arrangement was different to that carried out by Mr. Grundy. It did not follow because a different arrangement was in use there that the arrangement used by Mr. Grundy was not the best in his case. In the case of the Wigan Coal and Iron Company, the sinking was carried on day and night. One rope was winding coal and the other rope had a balance attached to it. There was an independent rope, which drew the *debris* from the sinking shaft up to the mouthing, from whence the coal was wound, and it was dealt

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with in the same way as Mr. Grundy had described. The arrangements were carried out by the electric light, and he considered they were perfect. Circumstances, of course, altered cases, and it might be the circumstances Mr. Grundy had to deal with were overcome the best way by his method. He had great pleasure in seconding the motion.

Mr. JOHN DEAN said: I have great pleasure in supporting the vote of thanks to Mr. Grundy for his interesting and instructive paper. With reference to the case of sinking spoken of by Mr. Unsworth, I can quite bear out his remarks that everything was as perfect as it possibly could be, and the sinking was carried out very successfully. I may say that about two years ago I had to sink one of the Standish Pits of the Wigan Coal and Iron Company an additional 90 yards, and as there would be about 300 yards of tunnel to be driven from the bottom of the new shaft, I came to the conclusion that sinking and tunnelling in the night time, with a tail-rope under the cage, would not be expeditious enough, so I decided to take the weights off the rods and secure them to bearers in the dib hole. The pit was 12 feet diameter, with two cages similar to Mr. Grundy's. We covered the pit with two sets of 12 in. baulks seven feet below the landing plate, for the bottom of the cages to rest on, and 18 in. below these another scaffold of 12 in. baulks, so that there would be no danger of anything falling down the pit on to the sinkers. We then drove a short tunnel out of the Cannel level and made a mouthing 16 yards below the original landing, similar to Mr. Grundy's two mouthings, and at this place we fixed a pair of 16 in. Hauling Engines, which we had at liberty, for sinking engines. We had boilers underground. We were thus enabled to work three shifts in the 24 hours, and the work went on continuously. The dirt was wound in hoppets and tipped down a shoot about six yards away from the pit, and then hauled up the

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short tunnel by means of a hauling engine on the surface, and sent to the surface in the cage as it came up. I may say we used doors instead of the ordinary jiddy, and found them much handier, but instead of the complicated arrangement of levers which Mr. Grundy seems to have used for opening and shutting, we had simply two chains running over pulleys and balanced by a weight which the banksman worked easily himself, both doors being opened and shut together. It is now about 18 months since we started sinking; in addition to the 90 yards of sinking we have put in 24 yards of mouthing, 17 ft. 6 in. by 12 ft. high, with steel girders and boiler plates, and also driven 240 yards of tunnel. With regard to the baulk scaffolds, above the sinkers, I may say that through a mistake of the banksman an empty tub fell from the surface down the pit, a distance of nearly 500 yards, and although the sinkers were working at the bottom of the pit at the time, they knew nothing about it.

Mr. C. Cockson thought it was a waste of time to compare the systems adopted. In some cases it might be worth while to put engines in and go to great expense, but he took it that in Mr. Grundy's case it was not worth while, and that he could effect his purpose best in the manner he had described.

Mr. Grundy, in reply to the vote of thanks which was heartily passed, said it took all their time to keep pace with the get, and it would have meant a considerably reduced output had they adopted another plan. With reference to the levers his idea was to open both the doors at one time, and by so doing they got the work done quicker, and it was safer. There was no break in the working except during the shot firing.

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THE SUBSTITUTION OF IRON AND STEEL FOR TIMBER IN MINES.

Discussion was then taken on the paper read at the last Wigan meeting by Mr. I. Johnson on this subject.

The PRESIDENT: I should like to know if any members have had experience of creosoting timber, or of pickling it in strong brine for the purpose of increasing the durability of timber in wet mines. I think if we could have figures relating to a method of that description, it would be very useful in a discussion of this kind.

Mr. J. UNSWORTH said he had had a difficulty with timber, in its ordinary green state, not standing. Such timber would only last three or four weeks, but by substituting creosoted timber they could get it to last six, nine and twelve months, and there was a considerable gain in that. He had tried, and had now in use, steel bars and props, and he found, in certain circumstances, they were very useful indeed, and he had no doubt they would be more economical than timber, creosoted or otherwise; but he had plenty of instances in which steel bars and props would not answer at all. Where they had a roof on the "weight," steel bars were not the right thing, they would bend, and were not as easily straightened, as the makers told them. But where the roof was perfectly set, and it was necessary to maintain the road for any lengthened period, the steel bars would be an advantage. He tried to use them where there was an advantage, and where there was not, he let them alone. He did not think in any instance in a man's working place steel bars would be found to be an advantage. However durable they would be, there was extra risk of losing them in case of heavy falls, which might be too big to move, consequently

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in the great majority of cases in coal mines, timber would hold its own against steel and iron in any form.

The PRESIDENT: With regard to the difficulty of the bars bending, I believe some people send them back to the maker to put them through the rolling machine to straighten them. I can quite understand the difficulty of straightening girders at a colliery.

Mr. T. GRUNDY said they had used steel girders in driving a tunnel, but they had been up so short a time that their experience was hardly anything to go by. So far, however, the girders had acted very well. Of steel bars and props in the working places they had no experience whatever.

The discussion then closed.

MR. HALL'S PAPER ON MIS-SHOTS IN MINES.

The PRESIDENT invited further discussion on this paper.

Mr. J. GERRARD said in the discussion at the last Wigan Meeting on the paper, he made an allusion to an accident that occurred in connection with a detonator, and Mr. Bigg-Wither said that "the case mentioned by Mr. J. Gerrard of a shot hanging fire was the only one that had been reported from what might be considered a reliable source, but as the manufacturer of the electric fuse had assured him it could not possibly happen, and the experience had never yet been confirmed, it certainly was most improbable." He (Mr. Gerrard) had now a copy of a letter written by the makers, in which they said: "Now we have found occasionally that through some mishap in the manufacture, the small circular opening in the copper capsule is in some instances wholly and in others partially covered with metal,

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so that in such instances the fulminate would be quite covered, or only a very small portion of it exposed. When noticed by us, these defective ones have been rejected, and we have by us quite a number of such. Now, we believe, the ill-timed explosions have occurred with detonators such as these, which have escaped our notice. . . . . We are now using the ordinary detonators, without any inside copper capsule to intervene between the explosive mixture in the fuse and the fulminate. With this we think such a mishap would be impossible. We are sending Mr. Bigg-Wither a copy of this letter, and shall strongly advise him never again to use the patent capsule for electric fuses." He (Mr. Gerrard) wrote to Mr. Bigg-Wither saying he should be glad if he could attend that meeting, as he had a question to ask him. Did he receive a communication from the makers of the detonators? If he did, he ventured to submit it was entirely opposed to that which he stated at the previous meeting. It is of great importance that the facts and conclusions associated with accidents should be correctly recorded.

Mr. Cockson said Mr. Bigg-Wither was not there that day, but he was sure those who knew him would agree with him (Mr. Cockson) when he said he was a gentleman who would not make a statement to the Society which could mislead in any way He did not quite gather that the letter referred absolutely to detonators hanging fire. It might be that the letter read by Mr. Gerrard did not really refer to the case which Mr. Gerrard mentioned, and about which Mr. Bigg-Wither spoke at the previous meeting. As one who had used a large number of electric fuzes, he had dismissed the idea of an electric fuze hanging fire as being absolutely impossible, and he should have echoed what Mr. Bigg-Wither said if he had been present at the previous meeting. He did not think it was fair to close the discussion without

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giving Mr. Bigg-Wither an opportunity of giving an explanation, and he proposed that it be adjourned.

Mr. GERRARD seconded the motion, though he would not undertake to be present. What he had quoted was from the Transactions of the Midland Institute of Engineers. It was from a paper read by Mr. Rhodes, the manager of the colliery at which the accident occurred. The point was that the maker admitted the accident was caused by a *defective detonator*, and that that was submitted to Mr. Bigg-Wither. He was, therefore, surprised that Mr. Bigg-Wither stated so positively that he had had a communication from the maker denying that.

The motion was passed, and the meeting closed.

Since the Meeting, the following letter has been received from Mr. Bigg-Wither in reference to the questions raised by Mr. Gerrard :—

Gathurst, near Wigan,
12th May, 1893.

Dear Sir,

I much regret that I was unable to be present at the meeting in Wigan this afternoon, when the adjourned discussion was taken on Mr. Hall's paper, "Mis-shots in Mines." I am the more sorry I was absent as I understand the question Mr. Gerrard, H. M. Inspector, desired to ask me had reference to the reply I gave at the previous meeting concerning the case mentioned by him of the hanging fire of an electric detonator.

I cannot better explain the cause of the occurrence referred to by Mr. Gerrard than by quoting an extract from a letter I received from the maker of the electric fuse, dated 31st December, 1892, in reply to an acknowledgement of a copy of a paper he had recently read on electric blasting :—

"*Re* the point you remind me of as to 'hanging fire,' I had not forgotten it. The circumstances in that instance were, however, so

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peculiar that it cannot be considered, I contend, to be a case against electric fuses, but rather against *patent detonators*. If, as in this instance was the case, a detonating cap be used in which a metallic capsule effectually covers the explosive fulminate, leaving but a very small hole in the centre of it, I contend that the conditions are such as to make for failure to fire. Such an instance had never occurred so far as I am aware, with an ordinary detonator. In this case the electric fuse did not hang fire. It exploded, but the amount of the charge in the fuse was not sufficiently powerful to force its way past or through the paper head into the fulminate."

My company discontinued the use of these patent detonators some four or five years ago and my reply was intended, more especially, to refer to modern experience with the ordinary detonators. In my desire to be brief, I find that I did not make this point clear, and apologise to Mr. Gerrard for giving him the trouble of asking for a further explanation.

I should feel much obliged if you will include this letter in the minutes of your proceedings, as it is my desire to assist in throwing as much light as possible on the very important question raised by Mr. Hall's paper.

Yours faithfully,

H. BIGG-WITHER.

M. STIRRUP, Esq., F.G.S., Hon. Secretary,
Manchester Geological Society,
36, George Street, Manchester.

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1893

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XXII. SESSION 1892-93.

THE ORDINARY MEETING of the Members and the last of the Session was held on Tuesday, June 13th, 1893, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

WILLIAM SAINT, Esq., H.M.I.M., Vice-President, in the Chair.

Additions to the Library, January to June, 1893:—

Belfast Natural History and Philosophical Society: Report and Proceedings for Session 1891-92.—*From the Society.*

Cambridge.—Additions to Type Fossils in the Woodwardian Museum. Extract (Pamphlet form) from Geological Magazine, Vol. X., Decade 3, No. 345; 27th Annual Report Museums and Lecture Rooms' Syndicate for 1892.—*From Woodwardian Museum.*

Cardiff Natural History Society: Report and Transactions, Part 2, Vol. XXIV.—*From the Society.*

Chesterfield and Midland Counties Institute of Engineers: Annual Report, 1892.—*From the Institute.*

Camborne.—Mining Institute and Association of Cornwall: Transactions, Part 1, Vol. IV.—*From the Institute.*

Cornwall, Royal Institution of: Journal, 1890-91, Vol. X., and No. 2, Vol. XI.—*From the Institute.*

Edinburgh Royal Physical Society: Proceedings, Part 2, Vol. XI.—*From the Society.*

Essex Naturalist: Journal No. 12, Vol. VI., and Nos. 1-5, Vol. VII.—*From the Essex Field Club.*

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Glasgow, Geological Society of: Transactions, Part 2, Vol. IX.—*From the Society.*

——— Natural History Society of Glasgow: Proceedings and Transactions (New Series), 1889-92, Part 3, Vol. III.—*From the Society.*

Hamilton, Scotland.—Mining Institute of Scotland: Transactions, Parts 7-10, Vol. XIV.—*From the Institute.*

Hertfordshire Natural History Society and Field Club: Transactions, Parts 3-4, Vol. VII.—*From the Society.*

Leeds Philosophical and Literary Society: Annual Report for 1892-93.—*From the Society.*

Leicester Literary and Philosophical Society: Transactions, Part 12, Vol. II., and Parts 1-2, Vol. III.—*From the Society.*

Liverpool Science Students' Association: Annual Reports and Proceedings, Sessions 1890-91 and 1891-92.—*From the Association.*

——— Geological Association: Journal, Vol. XII.—*From the Association.*

London Royal Society: Proceedings, Parts 317-320, Vol. LII.; also Parts 321-322, Vol. LIII.—*From the Society.*

——— Year Book of Scientific and Learned Societies of Great Britain and Ireland, 1893.—*Purchased.*

——— Institute of Mechanical Engineers: Proceedings, Nos. 3-4, for 1892.—*From the Institute.*

——— Geological Society: Quarterly Journal, Nos. 193-194, Vol. XLIX.—*From the Society.*

——— Geologists' Association: Proceedings, Parts 1-2, Vol. XIII.—*From the Association.*

——— Geological Magazine, Nos. 343-347, Vol. X.—*Purchased.*

——— Iron and Coal Trade Review, Nos. 1303 and 1311, Vol. XLVI.—*From the Editor.*

Manchester.—Salford Royal Museum: Annual Report, 1891-1892.—*From the Museum.*

——— Literary and Philosopical Society: Memoirs and Proceedings, Vol. VI., Dr. Joule, 4th Series; and Part 1, Vol. VII., 4th Series.—*From the Society.*

——— Geographical Society: Journal, Nos. 1-3, Vol. VIII.—*From the Society.*

Manchester Association of Engineers: Transactions, 1892.—*From the Association.*

Manchester and Salford Sanitary Association: Annual Report for 1892.—*From the Association.*

Midland Institute of Mining, Civil, and Mechanical Engineers: Proceedings, Parts 118-119, Vol. XIII.—*From the Institute.*

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Newcastle-upon-Tyne, North of England Institute of Mining and Mechanical Engineers: Transactions, Part 6, Vol. XLI.; Parts 1-3, Vol. XLII.; also Annual Report, Accounts, &c., for 1892.—*From the Institute.*

Rochdale Literary and Scientific Society: Transactions for 1891-92, Vol. III.—*From the Society.*

Swansea, South Wales Institute of Engineers: Proceedings, Parts 1-2, Vol. XVIII.—*From the Institute.*

Whitaker, W., B.A., F.G.S., The following Books and Pamphlets presented by:—

"Taconic System," and its position in Stratigraphic Geology. By Jules Marcou.

Unification des Procédés dans les Cartes Geologiques. 1882. By A. Heim.

Quebec Group in Geology. Address by A. R. C. Selwyn, LL.D., F.R.S., 1882.

Louisville Limestones, 1877. By James Hall.

Geological History of Serpentines and Studies of Pre-Cambrian Rocks, 1883. By Thomas Sterry Hunt, Montreal.

Taconic Question in Geology. Part 1, 1883. By Thomas Sterry Hunt, Montreal.

And sundry Pamphlets.

Annals of British Geology, 1891. By J. F. Blake, F.G.S.—*Purchased.*

On the Organization of Fossil Plants of the Coal Measures, Part XIX. By W. C. Williamson, LL.D., F.R.S.—*From the Author.*

Report of British Association for the Advancement of Science. Edinburgh Meeting, August, 1892.—*From the Association.*

Reports of H.M. Inspectors of Mines for 1892.—*Presented by J. S. Martin, Esq.*

Science and Art of Mining, Part 16, Vol. III.—*From the Editor.*

Reports on an Explosion at Park Slip Colliery, N.S.W. District, 26th September, 1892. By A. Young, J. P. Robson, and W. N. Atkinson.—*Presented by W. N. Atkinson, Esq.*

Mineralization of Minute Tissues of Animals and Plants. Address by W. C. Williamson, LL.D., F.R.S. Pamphlet.—*Presented by W. C. Williamson, LL.D., F.R.S.*

Twenty-third Annual Report of Committee of Tynemouth Free Library, for year ending December 31st, 1892.—*From the Committtes.*

Report for North Staffordshire District Mines, No. 10.—*Presented by W. N. Atkinson, Esq*

Some Recent Results of the Investigations into Local Erratic Blocks. Pamphlet. By S. S. Platt.—*From the Author.*

Three Museum Handbooks, 1893.—*From Owens College Museum, Manchester.*

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Index to the Author's Collective Memoirs on Fossil Plants of Coal Measures, Part 2. By W. C. Williamson.—*Presented by the Author.*

Geological History of the Rawdon and Boothorpe Faults in the Leicestershire Coal Fields. Pamphlet. By W. S. Gresley.—*From the Author.*

Hints for Guidance of Observers of Glacial Geology. By P. F. Kendall, F.G.S., Stockport.—*From the Glacialists' Association.*

INDIA.

Calcutta, Records of the Geological Survey of India: Part 4, Vol. XXV., also Part 1, Vol. XXVI.; and Handbooks of Commercial Products, *Iron*, No. 8.—*From the Governor General in Council.*

AUSTRALIA.

Adelaide, Royal Society of South Australia: Transactions, Part 2, Vol. XV., and Part 1, Vol. XVI.—*From the Society.*

Sydney, The Australian Mining Standard: A Record of Mining, Financial, and Engineering Progress, Nos. 213-216, Vol. VIII.; also Nos. 217-235, Vol. IX.—*From the Editor.*

——— Geological Survey of New South Wales: Department of Mines. Records, Part 2, Vol. III.—*From the Hon. the Minister of Mines.*

——— Royal Society of New South Wales: Journal and Proceedings, Vol. XXVI.—*From the Society.*

CANADA.

Ottawa, Canadian Mining Review, No. 12, Vol. XI.; also Nos. 1-5, Vol. XII.—*From the Editor.*

——— Geological and Natural History Survey of Canada: Contributions to Canadian Palæontology. By J. F. Whiteaves.—*From Director of Survey.*

Toronto, Canadian Institute: Transactions, No. 5, Part 1, Vol. III. *From the Institute.*

U.S. AMERICA.

Cambridge, Harvard College: Bulletin of the Museum of Comparative Zoology, Nos. 5-6, Vol. XXIII.; Nos. 1-3, Vol XXIV.; also Annual Report for 1891-1892, and Nos. 11-12, Vol. XVI., Geological Series; and No. 54 or Vol. VII., No. 2, Vol. II.—*From A. Agassiz.*

Report of Commission on Waste of Coal Anthracite Mining. Philadelphia, May, 1893.

Chapel Hill, North Carolina, Elisha Mitchell Scientific Society: Journal, Part 1, Vol. IX.—*From the Society.*

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Denver, Colorado Scientific Society: Extracts from the Society's Proceedings—Production of Columbous and Tungstous Oxides in forming Compounds of Iron and Tin. By William P. Headden. Pamphlet. The Latest Method of Electric Car control. By Irvine Hale. Pamphlet. A Review of the Russell Process. By L. D. Godshall. Pamphlet. On a Series of Peculiar Schists, near Salida, Colorado. By Whitman Cross. Pamphlet.—*From the Colorado Scientific Society.*

Michigan Mining School: Catalogue, 1891-1892—*From the School.*

Milwaukee, City of Milwaukee Public Museum: Tenth Annual Report. September 1st, 1892, to August 31st, 1892.—*From the Board of Trustees.*

Minneapolis, The American Geologist, No. 6, Vol. X.; also Nos. 1-6, Vol. XI.—*Purchased.*

Minnesota, Geological and Natural History Society of: Annual Report for 1891.

——— Mammals of Minnesota: Bulletin No. 7. By C. L. Herrick.

New York, The American Museum of Natural History: Bulletin, Vol. IV.—*From the Museum.*

Philadelphia, Franklin Institute: Journal, Nos. 805-810, Vol. CXXXV. —*From the Institute.*

——— Academy of Natural Sciences: Proceedings, Parts 1 and 2.—*From the Academy.*

Scranton, Pennsylvania, The Colliery Engineer: Nos. 6-11, Vol. XIII. —*From the Editor.*

Washington, Smithsonian Institution: Report for the year ending June 30th, 1890.—*From the Board of Regents.*

Halifax, N.S., Mining Society of Nova Scotia: Transactions, Parts 2-3, Vol. I.—*From the Society.*

Saint John, New Brunswick, Natural History Society of New Brunswick: Bulletin 10.—*From the Society.*

FOREIGN.

Berlin, Gesellschaft für Erdkunde: Zeitschrift, Nos. 4-6, Vol. XXVII., and No. 1, Vol. XXVIII.; Verhandlungen, Nos. 9-10, Vol. XIX., and Nos. 1-3, Vol. XX.—*From the Society.*

——— Zeitschrift der Deutschen Geologischen Gesellschaft, Heft 3, Vol. XLIV.—*From the Society.*

Brussels, Société Royale Malacologique de Belgique: Annales, Vol. XXVI., 1890; also Vol. XV., 1880, Part 2; Procés-Verbaux, Vol. XXI., Part 4, 1892.—*From the Society.*

Dresden, Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis, Nos. 1-3, 1891.—*From the Society.*

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Freiburg in Baden, Berichte der Naturforschenden Gesellschaft, Heft 1-4, Vol. VI.—*From the Society.*

Kazan, Russia, La Société des Naturalistes de l'Université de Kazan: Proceedings, 5 parts, comprising 20-30, 1893.—*From the Society.*

Lausanne, Bulletin de la Société Vaudoise des Sciences Naturelles: No. 109, Vol. XXVIII., and No. 110, Vol. XXIX.—*From the Society.*

Mexico, Memorias Y. Revista de la Sociedad Cientifica "Antonio Alzate": Nos. 2-8, Vol. VI.—*From the Society.*

Naples, Rendiconto dell' Accademia della Scienze fisiche Mathematische, Series 2, Nos. 7-12 and 1-2, Vol. VI., and Nos. 3-4, Vol. VII.—*From the Academy.*

Pisa, Atti della Societa Toscana di Scienze Naturali. Processi Verbali Adunanza del di 3 Dicembre, 1892, Vol. VIII.—*From the Society.*

Roma, Atti della Reale Accademia dei Lincei: Rendiconti, Fascs 11-12, Vol. I., and Fascs 1-7, Vol. II.—*From the Academy.*

St. Petersburg, Académie Impériale des Sciences de St. Petersburg: Mémoires, No. 14, Vol. XXXVIII., and No. 1, Vol. XL.—*From the Academy.*

Stuttgart, Separat-Abdruck aus Paleontographica: Vol. XXXIX.—*Presented by C. Roeder, Esq.*

Mr. James Grundy exhibited a portable electric lamp, simply constructed, with four dry cells, which he thought would be very useful for occasional work. It might be used in mines where a safe light was wanted for any special purpose, or in the house. It consisted simply of four cells connected with a lamp, by means of a switch, and when fully lighted was of three candle-power.

The Chairman: What length of time will it burn?

Mr. Grundy: I do not know how long it would burn continuously; but I am told the cells are equal to about 70 hours. To replace them would cost about 9s., so that the cost would be about 1½d. per hour. I think that lamps put up in this form, with *secondary* cells—especially at collieries where they have an electrical installation,—might well be used, with good incandescent lamps, to replace the dangerous torchlights and paraffin oil lamps about pit bottoms, stables, engine-houses, &c.

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The Hon. Secretary (Mr. STIRRUP) called attention to some communications he had received. The first was from the Smithsonian Institution, in America, relative to the Hodgkins Fund prizes which it was proposed to offer—namely, a prize of 10,000 dollars for a treatise embodying new or important discoveries in regard to the nature and properties of atmospheric air, and one of 2,000 dollars for the most satisfactory essay on the known properties of atmospheric air. The competition for these prizes was to be open to all nations. Another communication which the Secretary had received was from the Royal Society of New South Wales, Sydney, with respect to certain prizes they were offering for memoirs on subjects connected with the History of Australia.

FURTHER NOTES ON BOULDERS FROM THE COAL MEASURES.

BY MR. MARK STIRRUP, F.G.S.

The additional notes on Boulders from the Coal Measures that I propose to lay before you to-day refer, among others, more particularly to some interesting examples from the Lower Coal Measures at Bacup, Lancashire.

I have discussed in former papers, published in our Transactions (Vol. XIX., p. 405), and in the British Association Report, Manchester Meeting, 1887, some of the many interesting questions that surround the study of the erratics or boulders that are found from time to time in the coal seams and roof shales of the Carboniferous Formation. I have shown that it is not a mere local phenomenon belonging to our own district, or confined even to the English Coal

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Measures, but that it is one of wide-spread character, of which we find evidences in corresponding strata on the Continent of Europe, and in the United States. The story of these stray stones or erratics should be of particular interest to the physical geographer in any attempt to restore the geographical outlines of the British Isles during the carboniferous period, as they indicate the nature of some old coast line or land area whence they have been derived. Then, again, could we satisfactorily explain how or by what means these stones were conveyed to the positions where they are found; they would give us some insight into the character of the climate prevailing at the time of their deposit. For notwithstanding the many theories that have been broached, explanatory of the physical and climatic conditions obtaining at the time of the Coal Epoch, there are many queries still unsatisfied, for which it should be our endeavour as geologists to seek an answer.

Much has been said and written of late years as to the *recurrence* of glacial epochs, and that, what is known as the "Great Ice Age," must not be accepted as an exceptional episode in the world's history.

The occurrence of considerable boulder beds of Permo-Carboniferous age in South Africa, India, and Australia, is said to clearly indicate a period of low temperature at the close of the Palæozoic Epoch.

The question then arises, does the presence of these erratics in the fine sediments of the coal shales or in beds so uniform and free from foreign materials as those of the Coal Measures lend any support to the theory of *recurrent* glacial periods suggested in the works of Croll and Sir Robert Ball? Though such questions may be said to be of theoretical rather than of practical value, yet they are not without interest or profit to those reflective and inquiring

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minds that find "sermons in stones" and "records of the past" visibly written in the building-up of the earth's crust.

That these boulders are not meteorites, dropped into some primeval bog, as once suggested, is a proposition readily disproved by a microscopical examination of their structure and composition, hence some more natural explanation of their occurrence must be sought than that of a celestial origin.

With the object of gleaning all the information possible, I have endeavoured to create an interest in the search for these boulders among those engaged in the working or management of the coal pits, an endeavour which, I think, has already borne good fruit, in the numerous specimens that have been brought to the surface, which would otherwise have been probably unnoticed and unknown.

By recording the details of all the finds that become known to me, especially those belonging to our Lancashire Measures, a body of evidence, it is hoped, will be got together which will throw a little more light on the subject under review and explain more satisfactorily than hitherto some of the curious questions involved.

The boulders now to be recorded come solely from the Lancashire Coal Measures, and present for the most part the same characteristic features of those previously described, viz., well rounded or oval forms, resembling the ordinary beach-formed boulder or pebble, or river-rolled stones. These stones are usually coated with an adherent thin film of coal or black carbonaceous matter, derived from the matrix in which they have been embedded, which film is often lustrous and polished, after the manner known as "Slickensides." No striæ or markings such as those recognised as due to the action of ice are to be detected

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upon them. Found singly or in small groups, either in the coal itself or in the shale forming the roof of the coal seam, they give no indication, in most instances, of other than tranquil deposition.

The first that call for notice are three specimens from that productive gathering ground, the Astley Pit, Dukinfield, which have been sent in by Mr. Clay, the manager, through Mr. Tonge, and are now in the Museum, Owens College.

They are from the Roger Mine of the Middle Coal Measures of Lancashire, which is here worked at about 560 yards from the surface.

The largest one, some 14 or 15lbs. in weight, is a grey quartzite, similar to those described from the same pit by the late Mr. James Radcliffe (*Quarterly Journal Geological Society, Vol. 43, p. 599*), and referred to in my paper (*loc. cit*). It was found lying on the top of the seam, partly embedded in the coal and the superincumbent roof shale.

The boulder is flattish in shape, having the corners well ounded.

The second is from a similar position, some 7 or 8lbs. in weight, but more rotund in outline, and is also a grey quartzite.

The third is a triangular, flattish-shaped pebble of grey grit, 3 to 4 inches in long diameter, much impregnated with the black colouring matter of the matrix.

As these specimens, however, offer no special features, and are of a class forming by far the greatest part of these erratics as described in the papers previously referred to, I will pass on to others of more special interest.

These mentioned in the following list have all been examined, both microscopically and macroscopically, by Prof. T. G. Bonney, LL.D., F.R.S., to whom I am deeply indebted

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for valuable notes on their structure and mineralogical constituents, and for which I take this opportunity of thanking him.

The first, which I have numbered X, is from the Crumbouke Mine, Wigan, (Middle Coal Measures of Lancashire) contributed by Mr. Hayes, and is remarkable as the only one which has come into my hands from the Wigan district, which is not of the ordinary quartzite type. It is a well-rounded oval shaped stone, weighing about 1½ to 2lbs. Professor Bonney describes it as "evidently a felstone." "Under the microscope," he says, "we see (1) quartz grains, much corroded, enclosing the material of the ground mass, but in parts they exhibit crystalline faces — probably a crystal first formed was then corroded, then 'grew' some new faces. (2) Felspar crystals, very decomposed. (3) Smaller grains with a dark, dirty, spotty border; interior replaced by secondary products, most of the grains rather irregular in outline, but one or two rather hexagonal. The possibility of these being altered nepheline has been considered but I can get no proof, or probably these are small felspars of irregular form and very decomposed.

"All these constituents are embedded in a ground-mass consisting of a number of microlithic secondary products; evidently it replaces a glassy base, which was not very homogeneous (as is common in rhyolites, dacites, &c.)

"The rock might now be called a quartz-porphyrite—very likely it was once a dacite. It has a family likeness to a group of rocks common to Scotland, both in the Southern Uplands and in the Highlands, which belong, at any rate in most cases, to the eruptives of Old Red Sandstone age."

The other specimens are from the Lower Coal Measures in the neighbourhood of Bacup, the only district in Lanca-

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shire, which so far as I know, has contributed granite boulders from the Coal Measures, notwithstanding the fact that granite rocks are unknown in the locality.

I am indebted for these examples to my old and worthy coadjutors, John Lord and George Scott, who have taken a great interest in the search for these stones, which after their exhibition here, are destined to occupy a fitting resting-place in the small but interesting Museum of the Natural History Society of Bacup.

Professor Bonney reports on these as follows :—

No. XI.—(From roof of Gannister Mine, Fox Hill, Bacup. Oval-shaped stone, well rounded edges, measures 5 by 3 inches, weight about 1lb.) It is doubtful whether any constituent of this rock remains in its original condition. For the most part it is a mass of secondary products almost impossible to name with precision. In its present state it is difficult to fit the rock into a name. But I think the *history* is fairly clear—once it was a felspar pyroxene, holocrystalline rock, syenite, diorite or dolorite, probably the last. It underwent mechanical disturbance, which, to some extent, crushed it, and made it schistose; then much mineral change was set up.

It is the kind of rock difficult to localise; but it probably comes from a mountain region, and might very well have been derived from the Highlands of Scotland. Much of the secondary mineral change may be due to its lying "sopping" in a "coal bog."

No. XII.—(From Gannister Mine, Bacup. Oval-shaped stone, with well-rounded edges, 4 by 2½ inches, weight 12 to 14oz.) It is not of any particular interest. It has been a biotite granite, and is now in an advanced stage of decomposition. The somewhat composite character of some of the quartz suggests the possibility of a slight mechanical disturbance of ancient date.

No. XIII.—(From roof of Gannister Mine, Old Meadows Pit, Bacup. Oval-shaped stone, measuring 5 by 3 inches, well-rounded edges, one side much smoothed or flattened, weight about 1½lbs.) A biotite-gneiss (banded). The rock consists of biotite, quartz, felspar, the last being replaced by white mica, quartz, and secondary products, including perhaps a felspar, also a little iron-oxide, rutile, etc. Exhibits contortions well. I take it that this rock was first a

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banded gneiss,—(how originated I will not venture to say)—was then contorted, and probably somewhat crushed by mechanical movements; then underwent secondary mineral changes. Some of these, I expect, are very ancient. The biotite has not the tattered and torn look often produced by crushing; but looks as if it had mended again, and trimmed the edges of its crystals. So this may, very likely, be an earlier change than the mere decomposition of the felspar.

Rocks of this type occur in the Scotch Highlands. I should think it very likely to have come from there.

One of the objects sought to be attained by a microscopical examination of prepared sections of these boulders, such as those submitted to Professor Bonney, is to ascertain, if possible, their probable source or original home by comparison with similar or well-known rocks *in situ*.

The result of the examination of these Bacup specimens appears, however, to be indefinite and indecisive on that point, as Professor Bonney remarks, "The granite can hardly be localized, and the chances are in favour of the others being from Scotland."

The other chief problem awaiting solution concerns the means by which these boulders were transported, apparently for long distances from their original site, as no similar rocks are known in the vicinity.

The carrying power of moving water, as you know, is in direct ratio to the form and mass of the materials borne along.

Fine mud is carried far and held a long time in suspension; but pebbles, and large fragments of rocks, are moved comparatively but short distances, and soon fall to the bottom of the stream—the heavier ones first. Of course, in times of flood, the volume and force of water is greatly increased, and so the burdens it may then carry reach longer distances.

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Now the problem we have to solve is: how these boulders, some of great size, have been deposited in the coal shales, which are the fine muds of the period, indicating a tranquil deposit; while the pebbles and boulders betoken the force of, at least, some powerful freshet or flood.

One explanation has been, that these boulders have been entangled in the roots of trees, and thus carried on natural rafts for long distances, as is known to be the case in tropical rivers.

But will the purity of the coal seams and shales, and freedom from admixture with extraneous materials, permit of such an explanation as this?

That streams and floods rolled their turbid waters in Carboniferous times much as they do now, is testified by many examples of contemporaneous erosion, known to the miners as "horses," which are simply channels cut out of the mass of vegetation forming the coal seam; these channels being afterwards filled in with sand or mud during the Coal Measure period.

In the Pennant Sandstone, of the South Wales Coal Field, we have another instance of denudation during the formation of the Carboniferous rocks, in the beds of rolled pebbles and small boulders of coal which occur in the Sandstone, showing that the Lower Coal Measures of that area had been consolidated, and afterwards eroded, before the deposition of the Upper Coal Measures.

Instances such as these, however, while indicating the work of ancient rivers and the magnitude of contemporaneous denudation do not explain the isolated deposition of these boulders in the pure coal and shale of apparently undisturbed strata.

Then, again, we have the theory of a Carboniferous glacial period, suggesting glaciers, or sea-borne ice, as

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an agent of transport for the boulders, but sufficient proof of such an exceptional agent during the carboniferous age is not yet forthcoming.

The stones do not bear the impress of glacial striation, nor does the prolific flora of the period show any great climatal change, such as might be expected if glacial conditions had prevailed during any portion of that long period of time required for the accumulation of the material now forming our coal strata.

Our work, then, is simply to observe and patiently collect the facts as they arise, awaiting the finding of the clue which will lead us to a correct interpretation of the problem.

In order to show that such occurrences as I have attempted to describe are not restricted to the British Isles, but are world-wide in their manifestation, perhaps I may be permitted to read the following letter from Professor Orton, of the State Geological Survey of Ohio, a gentleman to whose good offices I have been indebted on previous occasions for information on this subject, gathered from the Coal Measures of the United States :—

State Geological Survey,
Columbus, O., May 12th, 1892.

MARK STIRRUP, Esq., Manchester, England.

Dear Sir,

Remembering your interest in the occurrence of boulders in coal seams, I forward herewith two small fragments of a boulder of vein quartz, recently taken from a mine near Youngstown, Mahoning Co., Ohio. The boulder lay immersed in the seam and about two feet below the upper limit of the coal. It is about six inches by eight inches, though the shape is irregular. Its surface is not at all worn or rounded, but the coal adheres very closely to the rock, as is shown in the samples sent. The usual slickensides occur in the adhering coal.

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The occurrence of this boulder is unique in the following respects, viz., (1) it comes from the lowest of our coal seams, in other words, the first in the order of time—the seam is not known to have yielded any blocks of this sort before; (2) its composition is peculiar, viz., vein quartz. All the other blocks in my possession are quartzites instead. (3) It lacks the rounded or worn surface that other such boulders have always shown.

The coal seam lies just above the Sharon conglomerate, and constitutes one of our inter-conglomerate series, but though the pebbles of the conglomerate are of the same composition, every one of them shows in its shape the abrading action of beaches or currents, and not one that I have ever seen contains more than two or three cubic inches in its contents.

Trusting that these facts will interest you in the study which you entered upon some years ago,

I remain, faithfully yours,

EDWARD ORTON.

(An article on this quartz boulder, by Professor Orton, was published in the American "Journal of Science," Vol. XLIV., July, 1892, a copy of which, sent by Professor Orton, has been deposited in the Society's Library.

Mr. Dickinson said: I beg to move a vote of thanks to Mr. Stirrup for the very interesting way in which he has brought this subject before us. It is an old friend; we have had it before us on different occasions; and if we keep it trotted out now and then we shall begin to think that these things really are boulders. At the same time I think we shall have to include in the same category all other aggregations we meet with of various kinds of minerals.

Mr. Gerrard: I have very great pleasure in seconding the vote of thanks. I am sure this Society is much indebted to Mr. Stirrup for his indefatigable perseverance

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in the collection of these specimens, and for bringing the subject before this meeting. We progress step by step, and I trust, in course of time, Mr. Stirrup may be able to favour us with a connected story, giving his explanation of where the boulders came from, and how they came to travel to the place where they were found. There cannot be any doubt as to the interest which attaches to these specimens, be they boulders or what they may.

The resolution was unanimously passed.

Mr. HALL said: I think these boulders are rather interesting, as proving that the coal seams were not formed *in situ*, but by transit. They go a long way to prove that the material was brought down by floods, and deposited in water.

Mr. WATTS: I think the author of the paper has rather undervalued the force exerted by moving water in propelling boulders. I have had a good deal of experience in regard to this matter, and I am not at all astonished at floods moving, from time to time, boulders very much larger than those which have been described to-day. You must bear in mind that when a boulder is submerged in water it loses a part of its weight equal to the volume of water displaced, and thus becomes an object that the water can move forward in times of flood. Then, again, barriers are formed: *debris* is thrown across a stream by natural feeders, and when the stream on the higher side gets filled up, you get there a power of momentum which helps to push forward the boulders.

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DISCUSSION UPON MR. DICKINSON'S PAPER "ON OUTBURSTS OF SOFT COAL AND GAS AT THE BROAD OAK COLLIERY, ASHTON-UNDER-LYNE."

(Part VIII., Vol. XXII., page 239.)

Upon this discussion being resumed, Mr. Dickinson read the following communication :—

When the paper was read, certain views were expressed respecting the causes of the outbursts, and a few respecting the prevention of recurrences and of accidents to the miners.

Dealing with those respecting the causes first, Mr. Gerrard gave his views at great length. He primarily had not noticed during the reading that the paper attributed the outbursts conjointly to pressure of overlying strata, as well as to pressure of firedamp, pressure of gas from spontaneous combustion, and expansion by heat, which overcame the cohesive force of the soft, slippery-faced sulphurous mining bed that overlies the hard bed; and he thought that the paper attributed the cause entirely to chemical action, which he attacked as valueless. The view given in the paper was, however, supported by Mr. De Rance, who instanced what he had himself seen in the cliffs of Lyme Regis.

I think Mr. Gerrard under-valued the effect due to chemical changes, although mainly we both attributed the principal cause to pressure of strata. As to chemical change, the mine is known to heat in the packs and sometimes to fire spontaneously; and that in most of the boreholes in the bed pressure increases, showing that some action is occurring, and we know that ordinarily, with an exception or two, heat produces expansion.

It is possible that conflicting chemical changes may be in operation in this mine. The increased pressure found

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in most of the boreholes may be mainly due to that from the firedamp, with an addition by expansion from heating; but some of this total may be lessened by the action which takes place in the formation of the carbonic acid or blackdamp found mixed with the firedamp.

The increased pressure yet found in the boreholes, only about 14lbs. to the square inch, is certainly very much below what has been proved in other mines at similar depths, and this may occur from condensation, as shown by the moisture found in the boreholes and seen in the haze accompanying some of the outbursts.

As to this probable condensation, all my observations of carbonic acid gas in mines lead me to the supposition that some such change occurs. I have read of carbonic acid gas having been met with in a mine under great pressure; but in the innumerable issues, when unmixed with firedamp, that I have experienced, not one has been under pressure.

There is also something worth noting on this subject that I have recently seen in a Paper by Mr. Arnold Lupton, on Spontaneous Combustion, that appears in Vol. IV., Part III., of the Transactions of the Federated Institution of Mining Engineers. Quoting from Richter's "Demonstrations," he states that:—"Newly cut coal will absorb oxygen; some coal absorbing 1¼ times its own bulk, and other coal three times its own bulk," and "active chemical decomposition of the coal takes place, forming carbonic acid and water, and that this decomposition is accompanied with considerable heat" —"the hotter the mine the more rapid the decomposition." There appears also in the discussion on Mr. Lupton's Paper a statement by Mr. Binn's, of Netherseal, who spoke from great experience of gob fires, "that they always found moisture sooner than the gob stink."

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There may be also some effect produced upon the cohesive force of the soft bed at Nook by chemical change.

In endeavouring to account for the preponderance of outbursts in the south levels, Mr. Gerrard attributed it mainly to firedamp kept back by the joints or cleets in the hard bed having a sloping direction southwards from the floor to the roof, and *vice versa* in the north levels. This may have some effect, but I think it will only apply to gas contained in the few inches of overlap, and it is likely to be much less than the effect due to the slanting direction of the engine brow which lets off less pressure under the south levels, and more from under the north levels.

I quite concur in the view that subsidence of overlying strata caused by working the coal may in some instances have some effect in bringing on pressure. It, together with a possible rolling down brow to the dip induced by the steepness of the seam, was a point mentioned by Mr. Higson in one of our interviews. Such subsidence is, however, an accompaniment of any system of working unless sufficient pillars are left for support; and even that is apparently not a reliable remedy for Nook, as some of the outbursts, notably that of May 2, 1890, shown on the plan, occurred when not any wide work was near.

The outbursts mentioned as having occurred in Belgian Collieries, I would rather not enter upon, without knowing the details.

Entering now upon the part of the discussion, relating to the prevention of the outbursts and accidents, which took place when the paper was read :—

Mr. Mills thought a remedy might be found by getting the coal on the dip in place of on the rise. That, however, is being done. Indeed, it was not until the workings on the dip were about 500 yards under cover that the outbursts

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began. Working on the dip, therefore, which has many advantages in contending with firedamp, is evidently not the cure required in this complicated case.

Mr. George Wild, another old experienced colliery manager, stated that in the same Royley seam, 700 yards deep, at Bardsley, situated in the same township as Nook, he mined or holed in the hard coal underneath the soft bed without having any outburst. The soft bed at Bardsley was, however, only about 6 inches in thickness. Had it been 18 or 24 inches, as at Nook, the gape or gap of the mining below might have helped rather than retarded the liability to outbursts.

Enumerating the precautions already taken, they consist of:—Trials of various methods of working, resulting in the present system: Driving wide, and driving narrow, and driving both quickly and slowly: Keeping boreholes in advance, with the view of letting off the pressure of gas; hitherto without success, but rather the contrary, in preventing outbursts. The other precautions which have been found useful are:—Enjoining the miners to keep a clear course behind for escape, and to be on the alert and inform the fireman when anything unusual occurs; such as hearing the coal crackling, or finding it more fissile or curly, or more gas given off; and to have warning given to their comrades in the return air, which might be dangerously fouled by the gas from the outbursts: The limit of 2 feet in depth has also, as an experiment, been put upon the extent to which mining or holing may be driven.

I shall be very glad to hear that further useful precautions can be suggested.

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The following letter, which had been received from Mr. Arnold Lupton, Professor of Mining Engineering in the Yorkshire College, Leeds, was read by the Hon. Secretary :—

6, De Grey Road,

Leeds, 8th June, 1893.

Dear Sir,

I venture to send the following contribution to the discussion on Mr. Joseph Dickinson's paper "On Outbursts of soft coal and gas in the Royley Seam, at the Nook Pit."

"I have read with the greatest interest Mr. Dickinson's paper, and also the remarks of Mr. Gerrard and Mr. Wild and others, and I venture to ask those who are practically acquainted with the Nook Pit if they think the difficulties in regard to any explanation of the cause of these outbursts can be reconciled as follows :—Taking, in the first place, the question of pressure as put forward by Mr. Dickinson, Mr. Gerrard, and Mr. Wild. The pressure being sufficient to reduce the coal to dust with no cohesive force, it can easily be blown out by a very slight pressure of gas. Over, however, the bulk of the mine the coal is sufficiently strong to resist crushing, and therefore cannot be blown out in great quantities so as to smother the workmen. It is only here and there that owing to some variation in the quality of the seam the pressure is sufficient to reduce the coal to dust. When this occurs, and at the same time there is a slight pressure of gas, the coal dust is blown out from between the upper and lower beds and the pillars of stronger coal which form the sides of the cavity.

"This explanation is consistent with the fact of blowers occurring in the close proximity of bore holes, because a bore hole will not let off the gas except at cracks, the rate at which gas can force itself through solid coal into a bore hole being too slow. It is also consistent with the circumstances mentioned by Mr. Dickinson of a blower reaching to within a yard of an upper level, the theory being that this last yard was uncrushed coal, and therefore easily capable of resisting the pressure that was sufficient to blow out the coal dust from below. It is also consistent with the fact noted by Mr. Dickinson that the deeper the holing was made the greater the liability to outbursts, because this holing would tend to bring a crush on the front of the coal; and where the coal was already almost crushed this would give the final touch. The front part of the

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holing would then be blown out, and the crushed coal or dust behind would come out by expansion of the gas in due succession. It cannot be supposed that a hole eight yards in depth would be cleared out by the pressure of gas at the back of the hole, because that would require such an enormous pressure. It is necessary to assume that the crushed coal or dust is mixed up with gas, so that each layer exposed comes out in rapid succession from the front inwards."

Yours truly,

ARNOLD LUPTON.

The Hon. Secretary, Manchester Geological Society.

Mr. G. H. Hollingworth read the following communication :—

THE "OUTBURSTS" AT NOOK PIT, BROAD OAK COLLIERY.

It is now nearly 20 years since I was connected with the Hurst Nook Colliery, but I have followed the record of these peculiar accidents with great interest.

During my time there was considerable trouble with gob fires, owing to spontaneous combustion of the "Minings," which were of the same soft nature as has been described, so that they could be crushed to impalpable powder in the hand, but none of these outbursts of the mining coal. I don't think we require to look further for the cause of these outbursts than to consider the mechanical pressure of the gas due to the depth of the strata, combined with the peculiarly soft, weak structure of the "Minings," which does not allow free outlet to the fire-damp enclosed under such enormous pressure, whilst being so weakly coherent it itself is blown off from time to time. The chemical constituents of the "Minings" easily account for the spontaneous

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combustion, but it appears impossible that in a borehole sufficient oxygen could be absorbed to cause the great heating that would be required to account for the outbursts; the heating up is a very gradual process; besides, you have the fact that the blowing takes place both with and without boreholes.

It seems likely that if the mine could be worked on a pure long wall system, affording greatly increased surface for gas drainage, there would be no difficulty with these outbursts, but I am well aware of the great, if not insuperable difficulty, of working the Royley Mine at Hurst Nook Colliery on that system. The steepness of the dip, the friable nature of the packing material, and the strong nature of the roof and floor, amongst other matters, make up a difficult combination.

It is fortunate that the condition of the mine which exists at Hurst Nook is not likely to extend over a large area. We have the "Tops" and "Minings" with the Royley Seam in the Oldham district, within two miles on the north-west in a very similar section to that at Hurst Nook, but the "Minings," though of a softer nature than the rest of the seam, are not so thick, nor are they as friable, as at the latter colliery, and I am working that mine at quite as great a depth as it is worked at Hurst Nook, without any sign of these outbursts. The Royley mine, however, changes very much on the deep or westerly side of the Hurst Nook Colliery, where the tops are not "on," as proved at Bardsley Colliery about a mile distant, and this remains a feature of the mine, so far as it extends on the south of the Colliery through Dukinfield, Bredbury, and Poynton, where the seam is known as the Woodley and Ridacre Mine, and is only about two feet thick, and has no mining sheds.

The Royley Mine at Hurst Nook Colliery is not the only mine where this difficulty has occurred, as the cases

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mentioned by Mr. Dickinson and Mr. Gerrard testify. The following translation of a paper by Messrs. Ichon and Lombard, which appears in the *Annales des Mines*, Series 9, 1892, will be of interest, and the suggestions contained may assist the present discussion. The translation appears in the Transactions of the North of England Institute of Mining Engineers, in Part 6, Vol. XLI., issued January, 1893, and is entitled "Instantaneous Outbursts of Fire-damp":—

"A number of sudden or instantaneous liberations of fire-damp, accompanied in some cases with sulphuretted hydrogen, occurred at Bessèges collieries from August 10th, 1886, to January 18th, 1892. They took place in two distinct districts (1) in a series of seams below the barren ground where the seams were worked at a depth exceeding 380 yards; both where flat and steeply inclined; (2) in a level cross-measure drift from the Brissac pit, which, after crossing the series of seams below the barren ground, and also a large fault, traverses the barren ground for 1,250 yards, and cuts other seams geologically above it. The Creal drift is now 3,290 yards long. The points where the instantaneous liberations of gas took place were from 490 to 600 yards below the surface.

"In the first district, twenty liberations occurred in four seams of coal. In the cross-measure drift, there were fifteen liberations in four seams, by one of which two miners were killed. Two other outbursts of gas are described which took place in stone drifts where there was no coal. No explosions resulted from any of the outbursts.

"After the fatality in the Creal cross-measure drift, additional precautions were taken when cutting seams of coal, as follows:—(1) Shots were fired only in the roof or floor of the seam, and never in the coal; (2) the shots were fired singly, with white fuze and safety lighters, or by electricity, safety explosives only being used; (3) the workmen retired during shot-firing to a special refuge, 150 or 200 yards from the face, made in the rock, with a strong door opening outward, and ventilated by a compressed air-pipe; a window in the door allowed a lamp placed in a niche outside to be seen; (4) in order further to diminish the chances of inflammation the Körting blower used for ventilation was stopped when shots were fired, so that if gas was liberated by the shot it might be less mixed with air.

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"In consequence of the entire absence of any warning of the outbursts in the Creal drift it was considered safer to endeavour to liberate the outbursts by firing shots rather than to advance by pick work with advance boreholes.

"The liberations of gas which took place in the seams below the barren ground were not, strictly speaking, instantaneous, inasmuch as they were heralded by certain indications. These were, first a hissing sound, then generally a louder noise, crackling in the coal, and cracking of the timber for a few minutes (sometimes three or four) before the outburst. In one case a workman was caught up to the knees in the projected small coal, and in another case a man was blown down by the gas before escaping.

"In most cases the lamps of the workmen were extinguished, and sometimes the fire-damp spread so rapidly and so far as to extinguish lamps at a distance, and fill hundreds of yards of roadways. Ten lamps were once extinguished at a distance of 375 yards in the return air-course. Most of these liberations were accompanied by a projection or detachment of the coal, sometimes from the face only, and at others from the sides or floor. In several cases the workmen at the moment when they heard the precursory noises could see the working face coming in on them as it were. The amount of coal thus projected was generally proportional to the quantity of gas liberated, and varied from a few wagons to 50 tons. There were also considerable mechanical effects. In one case four settings of timber were overthrown, and partly broken, a wagon was thrust three yards back, and filled with coal, the gallery being completely filled with coal for 5½ yards. The quantity of gas liberated varied much, in one case it was estimated that 28,000 cubic feet escaped in the first 150 seconds, and 176,000 cubic feet in 12 hours. The fire-damp was frequently accompanied by sulphuretted hydrogen, which was also sometimes given off in ordinary workings, and when in considerable proportion incommoded the workmen much more than the fire-damp.

"In most cases the coal contained about 20 to 23 per cent. of volatile matter, and the projected coal was very tender and friable, but in some cases the coal was harder than usual. In one of these cases the projected coal was covered with very fine dust in the form of soot. It was generally observed that coal which, before the outburst, was tender, became harder afterwards. The coal was sometimes so tender that a borehole could not be maintained in it. In no case did the bore-

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holes prevent a liberation of gas. (The same observation might be made of outbursts in Belgium, especially in the case of the enormous outburst at l'Agrappe, where the working face was preceded by several boreholes, 4 to 5 yards long.) Sometimes the outburst occurred after considerable surfaces of the coal had been exposed to the air for a long time.

"In some cases successive outbursts took place in short distances, a few yards apart. All these outbursts, except one small one, occurred in narrow places, eight in downbrows, six in levels, and five in stone drifts while crossing seams of coal. In eleven cases they occurred near irregularities and small faults or foldings.

"The liberations which occurred in the Creal cross-measure drift in the seams above the barren ground were more dangerous than those occurring below the barren ground. They occurred without any previous warning, and usually immediately after the firing of shots. Larger amounts of coal were projected, although the seams were harder and thinner. The coal was projected as much as 40 yards from the face, and in one case was partly in a state as fine as soot.

"The outbursts in the Creal drift were excessively sudden, and did not persist after the projection of the coal. The coal adjoining that projected was several times found to have a vertical laminated structure in the part next the roof, with interstices between the laminations. A vacant space between the coal and the roof was also several times observed.

"It might be supposed from these facts that besides the gas condensed in the particles of coal, there may have been gas in a free state in these cavities, and that it is to the existence of these cavities, exposed by boreholes, pick work, or shots, that the instantaneous outbursts are due, which, once commenced, are propagated in consequence of the rupture of the equilibrium.

"W.N.A."

This records 37 outbursts, in one of which two miners were killed, but no explosions arose therefrom. There is great similarity between these and Mr. Dickinson's description of the occurrences at Hurst Nook Colliery, and it appears that these outbursts will certainly have to be reckoned as one of the dangers to be contended against in

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working coal mines at considerable depths, when the coal itself, or the contiguous strata, is of a friable nature.

You will have noticed that sulphuretted hydrogen is mentioned as being given off at Bességes, that the depth of the mines where the outbursts occurred was 490 to 600 yards below the surface; that two outbursts occurred in stone drifts where there was no coal; that in most cases the coal contained about 20 to 23 per cent. of volatile matter, and was very tender and friable, but in some cases the coal was harder than usual; that in *no* case did boreholes prevent a liberation of gas, and that sometimes the outbursts occurred after considerable surfaces of the coal had been exposed to the air for a long time, and that all the outbursts except one occurred in narrow places.

Mr. James Grundy said: It would be difficult to follow these new papers in the several matters touched upon; but I have made a few notes on Mr. Dickinson's original paper, some of which apply also to Mr. Dickinson's remarks to-day, and to the observations of other gentlemen. And while about to say a few words on Mr. Dickinson's paper, I may say that there cannot be two opinions as to the importance of the subject, or the very able way in which Mr. Dickinson treated it. First, as to the question of pressure. Mr. Dickinson said that the outbursts began at five hundred yards below the surface—evidently denoting pressure; and I was glad to find that, in his remarks to-day, he attached importance—almost equal importance—to various things, pressure, chemical action, &c.; and he did not seem to rely so much on the chemical theory as he did in his original paper. As to pressure, I might give what I think would be found an approximate and very simple rule for determining

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the pressure of the strata; and that would be to reckon *one pound pressure per square inch for each foot in depth of strata below the surface of the ground.* I think that would approximately represent the pressure of the strata. Mr. Dickinson says—judging by the quantity of soft coal thrown out, and from localities where the bore holes were in advance, the issues come out of solid ground. With this I quite agree. There are no cavities found; but I go further and say that such phrases as "soft coal blew off," "spaces left," "cavities," &c., would be much better expressed—I mean to say the expression would much better represent the actual state of things—if we were to say that some part of the "minings" are displaced over such an area, the quantity that came out from the face being the *difference* between the quantity required to fill the part when in a solid state and that required to fill it when in a broken state. I mean by that, supposing the "minings" before they came out to be in a solid state, when broken up they would take more room, and it is principally the taking more room when displaced that causes the loose minings to project out from the face. When the minings are being shovelled out you find no space; and the sizes given of the areas and the cavities are, for that reason, entirely misleading. That is, in shovelling the loose minings out, after one of these outbursts, they keep on shovelling what appears to be loose; they never find any cavity; they follow it until they come to a place where the "minings" is a little harder than the rest; and when they have done shovelling out, that is given as the size and shape of the cavity. There is no cavity at all; it is merely a breaking up or a reduction of the "minings" into a pulverised state. Well, then, Mr. Dickinson to-day, and also in his previous paper, so far as I understand it, spoke of the haze as probably some effect of an increase of temperature. I would,

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however, regard the haze as being formed by cold rather than by heat. The gas when in the interstices of the "minings" is in a partly compressed state; that is, it has a pressure much greater than the atmosphere; and we all know that evaporation and expansion—evaporation being another form of expansion—tends to produce cold. That is well known in connection with air engines below ground—the expanding exhaust air has the effect of producing cold; and Professor Tyndall has often shown similar experiments as illustrating how fogs are formed, and how the expansion of air produces cold. The cold produced by expansion lowers the temperature until the air cannot hold the same quantity of vapour that it previously held, but gives up the vapour in the form of fog; and a few weeks ago Professor Dewar, at the Royal Institution, lecturing on liquid air, spoke upon the subject of fogs; and showed that by the expansion of air, but more readily when there was dust present, you get fogs always; so that the haze, in my opinion, is due to the compressed gas being liberated, expanding, and robbing the air—and perhaps part of itself—of some heat, thus reducing the temperature and its power to retain the quantity of moisture it previously held. As to gas robbing itself of heat; a good illustration may be found in compressed carbonic acid gas. It is the way chemists get solid carbonic acid. They first liquify it, and then allow it to pass through restricted chambers; and one part of the gas that escapes, and flies into the atmosphere, so robs the part left of its heat as to produce the carbonic acid snow, which may be handled. The same remark applies as to the temperature tests. Mr. Dickinson showed that, to find out whether the bore-holes did good or harm, they made temperature tests by putting a thermometer into the bore-holes, and that sometimes the temperature inside was higher than out-

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side. At other times it was cooler inside than outside. Well, there are no data to prove it, but I might venture to state my conviction that at the time when the temperature of the hole was hotter inside than out, there was no gas being given off—that everything was quiet and in its normal state, and the temperature registered was the ordinary temperature of the strata inside the hole, that had not been subjected to a cooling atmosphere; that when the hole was colder inside than outside there was more gas being given off than when the other test was made, and that the escaping gas—let it be from the part near where the thermometer happened to be at the time, or spread over a larger surface—brought about those conditions of cold that affected the thermometer and made really, at that part, the inside of the hole to be colder than the outside. Again, the paper seemed to indicate that possibly the heating was due to absorption of oxygen, but, in most cases—in the great majority of cases I should say—the tendency is for the pressure to be exerted from the inside towards the outside. You have the gas under pressure inside; it wants to come out, and does come out almost continuously, sometimes more copiously than others, and to such an extent that it will sometimes fire in a safety lamp, clearly showing that the pressure is least on the outside and, therefore, little tendency for gas to go in. Under these circumstances it is most unlikely oxygen would go in. The tendency of pressure, as I said, is from the inside to the outside; and so I repeat the data derived from these temperature tests are insufficient to base deductions upon, either for or against the practice of boring. After Mr. Dickinson's remarks to-day, I think it unnecessary to say much on the chemical question. It appears to me the matter has been considerably modified, but it is well worth noting that when a chemist speaks of iron bi-sulphide he is hardly speaking of the pyrites in a

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mine. The pyrites met with in a mine is not iron bi-sulphide; it is iron bi-sulphide *plus* many other things. The quantity, it may have been noted, in the first sample tested was only 26 per cent.; even if it had been pure, without the intermixture of foreign matter, the iron bi-sulphide was only 26 per cent. of the total of the "minings;" and where the percentage was greatest, in the most favourable sample (sample No. 2) it was only 41½ per cent. Sample No. 3 was about 24½; and No. 4 was 1¾. Thus, when the chemist says that the bi-sulphide of iron, when exposed to air and moisture absorbs oxygen with such avidity as to become red hot, that statement I should think should be taken as a comparative statement. I really do not want to say much on that, because I do not want to question, or appear to question, the analysts' statements. All I would say on that particular point is that I am afraid we are misrepresenting their statements; for, compared with other substances that oxidise, iron bi-sulphide does absorb oxygen with avidity, and does give off heat, as colliery people know very well; but it does not absorb oxygen to give off heat in such a comparatively short time as would appear to be indicated by Mr. Dickinson in his paper. Not at all, when they have gob fires, it takes weeks, many weeks—in fact sometimes as long a time as three months—after the material is stowed away, before the heating up is indicated, and having heated up, it takes many weeks to cool down. But supposing it did heat up so quickly, where is the practical evidence of it? There are men living who were present when the outbursts occurred, but they say they felt no heat. I believe they would have a greater sense of cold than of heat. There has been no burnt material found, and no smell, such as invariably accompanies oxidation and heating up of this bi-sulphide of iron. As Mr. Gerrard said after the reading of

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Mr. Dickinson's paper, he was present—and so was I—within six hours after the outburst on the North side, and there was not the slightest trace of any heat, neither in the material itself nor in the temperature of the air, nor anything that the men had experienced—not the slightest trace of heat. If there had been heating, its effects would have been felt for hours—probably days—after. Then, speaking of the expansive force of heat, of course when gases are heated they do expand; but what would be its effects if it was local? That would not be much; and even if it was spread over a greater area, to give a fair amount of pressure it would require a very high temperature. The whole of the gas in the "minings" over a moderate area would have to be heated to produce the pressure. It would require 273 degrees Centigrade, or 490 degrees Fahrenheit *increase* of temperature, to double the pressure by heat alone; but if you take it that the gas occupied, say, only one-tenth part of the volume of the "minings," you have only to suppose a very slight pressure to come in to give a pressure equal to that of a very high temperature. Taking the "minings" as being 20 inches thick, if the gas occupied a volume equal to one-tenth of the whole volume of the "minings," and if the roof and floor, by sinking or lifting, or both, had come one inch nearer together, that compression of 20 inches into 19 would double the pressure of the gas whatever pressure that might be. To test roughly the avidity with which this stuff called iron bi-sulphide absorbs oxygen, I some months ago took a piece from one of these large masses. Here is a part of it: it has not absorbed oxygen yet, so as to give off any heat that I can detect with the thermometer. To go a step further, I had this piece about one-third in water for three days: I had a thermometer in contact with it, and in the water, and another thermometer hung up in the same room not far

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from it. The two thermometers read exactly the same from beginning to end.

Mr. HALL: Did that come out of this particular seam?

Mr. GRUNDY: Yes, from the same "minings." The samples were taken from the locality of the last outburst. To carry the experiment still further, I ground a lot of the stuff up and put water to it, and here it is now, with the thermometer attached; and, comparing that with another thermometer hanging up in the same room, they have for about three days recorded the same temperature.

Mr. HALL: That is 69 degrees.

Mr. GRUNDY: I attach considerable importance to this chemical theory, because I fear, if accepted, it would have a tendency to make us feel we could do very little more—that here are the chemical effects, which are beyond our control, and we must take the consequences. I do not say that it would have that effect, but that would be the tendency. We might not do as much as we otherwise would, if we were to accept this chemical theory. Then, as to the *remedy*, I have not much hope of anything being found that will prevent these outbursts. I attach much greater importance to being able to take such precautions as will prevent accidents to the persons working in the mine. That is to say, it matters little whether we have outbursts or not—comparatively little—provided no one receives injury from them. As to the *precautions*, Mr. Dickinson stated in his paper that all the outbursts have occurred when men were present, and from the faces of new drivings, and also that some warning was generally given before an outburst occurs. He gave some valuable precautions (page 250 of the Transactions), and these he has repeated to-day. May not the warnings be sufficient if the

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men are sufficiently on the alert to enable them forthwith to apply the warnings and so make their escape? Mr. Dickinson knows, and I know very well, that we know much more on that particular part of the subject than one would care to say in a public meeting. Although my experience does not extend nearly so far back as Mr. Dickinson's, I remember the time when an outburst was thought very little of. The men are not even yet educated up to it, although the matter has been so serious. I can recollect the time when a serious outburst occurred, part of the mine filled with gas, lamps were put out, but the men escaped; and when the ventilation was restored they went back to work and thought no more about it. They did not even consult the fireman, or anybody. I say then, with all deference to the men, that they are not educated up to the point of taking adequate precautions. I do not for a moment say that they are careless or reckless, but coal has to be got, and the tubs have to be filled; and although they may not attach more importance to the filling of the tubs than to the care of their own lives, yet the uppermost thing in their minds is the work they have to do and the money they have to earn. One precaution that has already partly been taken, and might be still further extended, is the putting of the men on day work. Make their safety the first consideration. I would not have men who would idle about, because it is the idlers who would be most likely to get covered at the time of an outburst. They should be men with enough honesty to work, and at the same time make the general safety the chief thing. I say they have partly adopted that precaution, because they have put a man on to have the oversight of a few places and take charge of the work. But if it was thought unadvisable to put the men on day work then the next step might be to prohibit mining—I mean working in the "minings" itself, except where a responsible

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and very careful person is present to watch the behaviour of the strata and the gas, and take advantage of the warnings. In the case where the three men were lost, on the south side, they had such a man, but there had been mining in his absence; and many cases could be recited where the men really have had warnings, but by doing the work in a certain way and neglecting those warnings they could do so much more work, and do it so much more easily, that they have thought lightly of the danger, and so the circumstances have come about which Mr. Dickinson has described. Then, as to borings: I am in favour of borings, but I would extend the size of the holes. I would have good large holes so as to offer a large drainage area, and to ensure less liability to be blocked by the crushing of the "minings," and if the minings did crush into the hole it would extend the drainage area. Small boreholes have become blocked; for example, a hole 2½ inches in diameter was bored to liberate the gas, and left. On being afterwards examined the hole was found blocked, and while the man was standing in front of it the pressure of the gas had become so great behind the "minings" that blocked the hole that the minings were blown out in the man's face. As a proof that boring may do good, I will give a few particulars of one or two cases. In three cases I believe it did a great deal of good, and probably in many more. According to the testimony of men most closely connected with the work it, in their opinion, prevented an outburst. Mr. Ramsden, the manager, at the last meeting when this subject was discussed, very graphically described a boring which, to my mind, was proved to have done good; though I have an impression that, at the meeting, it was taken in the opposite sense, and was supposed to have done harm. Now I will give a description of a similar one. The statement is that all was quiet before

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beginning to bore. The "minings" were a little set and clayey at the front. When the hole was three feet in altogether the men began working the "minings,"—bottom coal and altogether,—gas being given off in the hole that would fire in the lamps. It became so bad that they temporarily left off boring. Work ceased for about half an hour, when it went quiet again, and the boring was recommenced. When the hole was 4½ feet in, crackings began again all along the five yards of the face of the working, as if the minings would blow out; and firedamp was given off. All the men were then withdrawn from the place for the day. On the following morning the same borehole was completed to 9 feet, when it was quiet and no gas was given off. Evidently the borehole had let off the gas, for although the boring was completed to 9 feet, after being left all night at 4½ feet, neither the absorption of oxygen nor the heat produced had the effect of increasing the pressure. The boring let off the gas, and when the hole was made 9 feet deep all was quiet. This was on the north side. Take another case from the south side. A boring began to give off gas freely at 3 feet deep, and it continued to do so for a considerable time. In this case the boring was stiff for 3 feet; then it went soft, and there was a blowing noise like steam blowing off. The disturbance made the hole 14 inches high and 6 inches wide; and when 3 feet of minings were got off on the following day the borehole began again to make a great blowing noise. In conclusion, I would like to add my tribute to the care taken by the officials, the owners, and all connected with this mine, and the value to the mining community of putting the matter in Mr. Dickinson's hands to bring before us. At the same time we must not expect them to adopt all or any of the recommendations we make without carefully weighing all the pros and cons. Recommendations on so important a subject should be made deli-

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berately, in conference with those who are responsible; and I, for my part, have considerable diffidence in making any recommendations in a public meeting. It is much better, I think, to go over the matter fully, from all sides, with the responsible parties on the spot, and determine what is best to be done.

The CHAIRMAN: As to the hypothesis of chemical action being an active agent in these outbursts, I think it would be well to emphasise an important fact, namely, that the outbursts occur only in comparatively new and narrow drivings, and that when the pillars have been worked after standing a considerable time, an outburst has never occurred in the pillar workings, the cleavage planes of the coal having, probably, been disturbed by the superincumbent weight, thus allowing passages for the gas to escape from the "minings." Now, if the chemical theory—or, to speak more correctly, the chemical hypothesis—was sound, we should expect to find some evidence in its favour in the pillars which have been exposed to the atmosphere for a great length of time, rather than in the faces of new drivings which have only been exposed for a few hours. But it is purely negative, and I, therefore, think we may safely eliminate the chemical proposition in considering the probable cause of these outbursts. I think they can be satisfactorily accounted for if we take into account the superincumbent pressure, which at the deepest part of the mine is, probably, not less than 2,000 lb. to the square inch, and the presence of large volumes of compressed gas in certain areas of soft coal, or "minings," surrounded by a mixture of fire clay and other material, which imprisons the gas until it is liberated by the miner. In the last fatal outburst such was evidently the case. It occurred suddenly, displaced about 30 tons of "minings," and smothered three

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men.—[The Chairman explained this by a diagram on the black board.]—I think this outburst was the result of nothing more than pressure and gas. In the first fatal accident, on May 2nd, the survivor was caught by the blown-out "minings," and embedded up to his arm pits; and he remained in that position for two hours, until the fireman found him in his round of inspection. At the inquest that man gave evidence, and he said he experienced no difficulty in breathing. Certainly, if there had been any fume coming off—such as sulphurous fume from iron pyrites—he could not have failed to notice it. Then there is another point that may be stated as evidence of the absence of great heat: the gas does not fire. If there was great heat in the "minings" blown out, I take it, the moment the "minings" met the fresh air they would blaze up and fire the gas. But nothing of the kind has occurred.

Mr. Hall: I have not had an opportunity of seeing this mine at Ashton; therefore I am afraid anything I may say on the subject of the outbursts will not be very valuable. I think it is very difficult to say positively what is the cause of these phenomena which Mr. Dickinson has brought before us; but we know that similar phenomena have occurred in Belgium and also in South Wales; and there they have always been set down to the pressure of gas, and crush. I never heard it advanced that the chemical oxidation of iron pyrites had anything to do with the matter, and, so far as I am able to judge, I think there is little in that argument. If the heat was developed which has been spoken of, we should have had evidence of it in the mine. We should have had a great rise of temperature in the air, but such a thing has not been mentioned in the paper, and I presume was not observed. Besides, as Mr. Grundy has partly pointed out, if the air could get in to

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oxidise the pyrites, then certainly the pressure could get out. If there was a road in for the air, there must have been a way out for the gas Mr. Higson, I think, complimented himself rather prematurely. He said that he had focussed the cause of these phenomena; but my impression is he must have had an instrument of intense magnifying power to do so. Then as to the question how we are to deal with these outbursts? That is a most difficult and at the same time most important matter. In Belgium, so far as I am aware, they are dealt with by boring, and I think perhaps the boring is, or at any rate ought to be, the best way of getting quit of the high pressure. I am disposed to think that this high pressure in the seam arises through the coal—the soft coal, as they call it—being so dense that the gas cannot escape as it does usually from ordinary coal. It is also, I think, just possible that if they were to give up holing in this soft coal, and hole in the bottom of the seam, that might be partly a remedy. I am also disposed to agree with one of the members who suggested that they should work this seam wide work. If they worked it wide work, they would have a much better opportunity of getting quit of local high pressures.

The Chairman: As to the adoption of a system of working, I think if some system could be adopted that would bring about similar conditions a few yards in advance of the face to what they find in the pillars when they come to work them out the gas would be relieved and the pressure would disappear. But the soft "minings" would not bear undermining. They fall off. They have no cohesion whatever.

Mr. Hall: But you would have some coal between them and your holing.

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The CHAIRMAN: Yes, but when they "fall" the coal the "minings" would also come down and mix with the coal. The subject is complicated by reason of the "minings" being liable to spontaneous combustion, necessitating the working of the mine on conservative lines.

Mr. DICKINSON, in replying upon the discussion, said: It is rather a late hour for me to attempt any reply, in detail, to what has been said. I think that many of the points raised have been already answered by the paper and in the remarks I made in resuming this discussion. The principal attack has been directed against the chemical theory; and some of us, with our little smattering of chemical knowledge, have called in question people who stand in the shoes of Professor Calvert, who was an ornament to this city. There was a time when Professor Calvert used to come to our meetings, to enlighten us a little; but he gave his views principally through the Literary and Philosophical Society. I wish that we could have had his successors here to stand up for their own analysis—an analysis which I think is entitled to respect. Some of the contributions, in the discussion on the facts, adorn the paper, and elaborate it very considerably. These, I think, are very welcome. But how few are the additions that have been made to the precautions already taken. Mr. Grundy sheltered himself by not liking to give vent in a public meeting to the views he held, but he did venture to say that they should go on boring and that the boreholes should be larger. Now, we had the owner of the colliery here when the subject was introduced. —I am sorry that ill-health prevents her attendance to-day—and she stated that the boreholes were, many of them, four inches in diameter, and that they fretted away to such a degree as to admit of a safety lamp being inserted.

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Surely that must be considered large enough. There was nothing to show that the orifice is too small to admit of the gas getting vent. Another of Mr. Grundy's suggested precautions was to have a responsible person present to overlook the men. But really I hope mining is not coming to that pitch—that every workman must have placed over him an attendant called a responsible person to see that he obeys orders. Indeed, it seems that on the occurrence of the principal outburst, when three lives were lost, there was such a person actually on duty. Then we have statements with regard to outbursts in Belgium. There it is said the precaution is boring; but, judging from the large number of accidents mentioned by Mr. Gerrard at the last meeting, it would seem that the boring does not produce any effect in preventing the outbursts. We have also had the outbursts at Bessèges brought before us by Mr. Hollingworth. There, it was specially stated, boring produced no effect. Mr. Saint thinks the chemical theory may be eliminated from consideration, and the whole cause attributed to the presence of gas. One part of what I brought before you to-day bears upon that: it is that the chemical change which is taking place may alter the compactness and enable the pressure to operate more readily upon the mass of soft coal. I have not heard that touched upon by any of the gentlemen who have spoken. Another point which has been unnoticed is whether the Belgian and French mines, where outbursts have taken place, are liable to spontaneous combustion, such as exists at Nook. Then, again, Mr. Gerrard and Mr. Grundy failed to find heat on arriving six hours after an outburst had taken place at Nook. I should not expect that they would. The heating takes place very slowly, and if you refer to the paper you will find it stated that no pack ever fires until the fire-stink has been smelled for a fortnight.

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Mr. HALL: But when this chemical action is going on it is always hot.

Mr. DICKINSON: There would be a little heat; but it takes a fortnight in the gob before the heating gets to be a fire. Mr. Lupton, in the letter which has been read, gives conclusions which harmonise closely with those in the paper. His view that the issue of fire-damp is chiefly from cracks requires some limitation, as issues are sometimes quite steady in seams without any backs or cracks present. Mr. Lupton is a well-known authority in scientific mining, and I see he approves of the limit of two feet as the distance to which the holing may be extended; but beyond that he does not add anything to the list of precautions. In fact, the discussion has elicited very few suggestions of additional precautions to those already being taken. The fact of these outbursts taking place has an interest in itself; but the practical point is—What further precautions can be taken so as to lessen the danger to human life in the mine?

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NOTICE.

The ANNUAL and next meeting of the Members will take place on Tuesday, the 10th October, 1893.

The LIBRARY is open for the use of the Members during the recess.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XXII. SESSION 1893-94.

THE ANNUAL MEETING of the Members was held at the Rooms of the Literary and Philosophical Society, George Street, Manchester, on Tuesday, October 10th, 1893. Mr. JOSEPH DICKINSON, F.G.S., Vice-President, in the Chair.

The Hon. Secretary (Mr. STIRRUP) read the annual report of the Council, which was as follows:—

REPORT OF THE COUNCIL,

FOR SESSION 1892–93.

The Council, in presenting the Fifty-fifth Annual Report, have to record the progress and completion of a session of good average work and undiminished prosperity.

In reviewing the events of the past year, it is usual in the first place to examine and revise the list of members in order to gauge the loss and gain, as some rough criterion of the present vigour and future prospects of the Society. It will be seen from this analysis that the obituary exceeds that of the average of many former years.

The Society has to mourn the loss of several of its old supporters bearing well-known and honoured names, among which is that of its President for the year, Maskell William Peace, F.G.S., the first instance in the history of the Society of the death of its President during his term of office.

The others to which death has laid claim are the Right

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Honourable the Earl of Derby, a member of upwards of 30 years' standing, William Bryham, J.P., R. T. Burnett, F.G.S., John R. Hewitt, of Derby, Walter Jamieson, of Glenarm, John Speakman, Thomas Statter, J.P., and Sir Richard Owen, D.C.L., F.R.S., an Honorary Member.

In addition to those removed by death and resignation, several names have been struck off the list owing to the non-payment of subscriptions.

Notwithstanding these deductions, it is gratifying to find that, thanks to the accession of new members during the year, the roll of members has suffered no diminution.

The list is now made up as follows:—9 Life, 13 Honorary, and 200 Ordinary Members, making a total of 222, the same number as at this time last year.

The number of Ordinary Meetings held at the Literary and Philosophical Society's House, 36, George Street, Manchester, was increased by an extra one in May, rendered necessary for the reception of the paper on "The Results of the Marston Boring," and two meetings were held in the Mining School, Wigan, as usual.

The Annual Réunion of the Members at the Geological Museum, Owens College, took place on Friday evening, 27th January, 1893, when Professor Boyd Dawkins gave an interesting address on the Coal-Fields of New South Wales, illustrated by a fine series of fossils belonging to the Museum Collections.

The Council thank most cordially the contributors of papers, some of which are important additions to our knowledge of the geological formations of the British Isles and of the Colonies, while others are concerned with the practical working of our coal-mines and the diminishing of the dangers and difficulties connected therewith, oft resulting from those greater depths which are now being opened up.

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Among the former may be mentioned the paper by Mr. C. E. De Rance, F.G.S., "On the Results of the Salt Union Boring at Marston, near Northwich," which details the first serious attempt to pierce the Red Rocks of Cheshire in order to reach the concealed coal-field which is so confidently believed to underlie them.

It must be a matter of general regret that the unforeseen great thickness of the Triassic rocks—so much more than had been estimated—resulted in the abandonment of this bold venture.

Professor Boyd Dawkins in his address on "The Coal-Fields of New South Wales," pointed out how recent explorations had been the means of adding a considerable tract of coal-bearing strata to the already-known large field of workable coal in that Colony, thus augmenting its future resources and wealth.

Mr. Joseph Dickinson's important paper, "On Outbursts of Soft Coal and Gas in the Royley Seam, Broad Oak Colliery,"—a paper which gave rise to considerable discussion,—had for its chief object the consideration and adoption of a system of working, whereby the safety of the workmen should be secured, while employed in rendering available to public use, a seam of coal, which, owing to local conditions requires special care and skill in the getting.

A contribution of great economic interest by Mr. De Rance, "On the Relation of Geology to the Population and Agriculture of England and Wales," with a valuable series of tables of statistics, shows the intimate connection of geology with agriculture and its influence upon the distribution of the population.

These communications, with others of a more or less scientific and practical value, show a commendable interest, on the part of the members, in the proceedings of the Society, which the Council trust will not be allowed to flag,

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and that individual members will endeavour by every means in their power to increase its usefulness.

At the beginning of the session it came to the knowledge of the Council that a few of the members desired a change of the day and hour for holding the monthly meetings.

In order to ascertain the wishes of the members on this point, post-cards were sent out to all the members asking for an expression of opinion on the subject, with the result that a considerable majority voted for the continuance of the present arrangements.

Should, however, a sufficient number of members, desirous of having a few *evening* meetings, agree to support their initiation, the Council see no difficulty in attempting the experiment.

It will be remembered that in the early part of this year, a circular was addressed to the members and the coal-owners and lessees of Lancashire and Cheshire, asking for their assistance and co-operation in the work which the Society is hoping to accomplish of giving a fairly accurate enumeration and description of the fossils of the coal-bearing rocks of this district.

Instructions were given to carefully note the exact horizon and locality from which each fossil was derived so that an attempt might be possible to correlate the various coal seams in different parts of the county, thereby rendering valuable aid to future explorations for coal.

The result of this appeal has not, as yet, been such as the Council had reason to expect, but it is hoped that the object has not been lost sight of, and that considerable additions to our knowledge of the fossil fauna and flora of the Coal Measures will yet be forthcoming from the hands of the members and others interested in the work.

Several members have already responded by sending specimens, whose assistance will be acknowledged and their

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contributions incorporated in the next list of Fossil Plants, &c., which is being prepared by Mr. Robert Kidston, F.G.S., for publication in the Society's Transactions.

Excursions.—Two excursions were arranged to take place in July to districts of geological interest, Mr. De Rance, F.G.S., having kindly promised to conduct both.

Only one, however, came off, that to the Triassic rocks of Alderley Edge, to see the junction of the Keuper and Bunter Sandstones and the underground workings of the old copper and cobalt mines. The excursion was a pleasant one, and thoroughly enjoyed, and had the advantage of a local leader in Dr. Davies.

The excursion to Macclesfield to view the high-level glacial drifts of the neighbourhood, necessitating the traverse of a somewhat long stretch of country, was abandoned, owing to the difficulty of obtaining vehicles on a Saturday afternoon and the failure to arrange any other day of the week suitable to the majority of those who had promised to go.

Library.—The Council are pleased to report a more extensive use by the Members of the books and maps in the Society's possession, a fact perhaps due in large measure to the recently issued new catalogue. One valuable section of the Library, to which additions are constantly accruing, is that of the publications of the principal home and foreign Societies having kindred objects and like aims to our own. These institutions receive in exchange the Society's "Transactions," thus tending to create a solidarity or fellowship of world-wide extent. This community of interest is often evinced by the request for special papers or parts of the Transactions received from correspondents in the Colonies, the United States, and the Continent.

Among the recent additions to the Library may be noted the following works:—

Fossil Botany, by Solms-Laubach.

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Explosives and their Power, by M. Berthelot.
Text-book of Coal-Mining, by H. W. Hughes.
Physics of the Earth's Crust, 2nd Edition, by O. Fisher.
Annals of British Geology, 1891, by Professor Blake.
Aids in Practical Geology, by Professor G. A. J. Cole.
Palæontographical Society, Vol. XLVI., 1892.

The Balance Sheet, with particulars of the income and expenditure, prepared by the Honorary Treasurer, Mr. H. M. Ormerod, will be laid before you, and its examination will testify to the very satisfactory state of the Society's finances, as well as to their careful administration by the Treasurer.

The last Balance Sheet showed an amount of £205 13s. 2d. standing to the credit of the Society; of this sum, a large part has been appropriated to the purchase of £150 Lancashire and Yorkshire 4 Per Cent. Perpetual Preference Stock, which the Treasurer, acting on the instructions of the Council, has bought at a cost of £196 6s.

This will raise the invested funds to £1,150.

The Society at present stands in the enviable position of having no debts, all claims against its funds having been discharged with the result that there remains a balance in the hands of the Treasurer of £25 13s. 8d., after payment for the aforesaid purchase of Lancashire and Yorkshire Preference Stock.

In concluding this resumé of the Society's operations during the past sessional year, the Council, while congratulating the members on the satisfactory results shown, owing principally to the devotion and energy of a few members, would respectfully urge upon that larger body, who hold themselves aloof from personal participation in the work of the Society, to lend their aid to promote its efficiency.

Each and every member might contribute something beyond his subscription to the furtherance of the objects of the Society, not only by offering papers or short communica-

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tions on subjects likely to interest his fellows, but by a more frequent attendance at the meetings, by participation in the discussions, and by inducing his friends to join the Society.

The utility of an association like the Manchester Geological Society, whose objects are the collection and diffusion of practical and theoretical knowledge respecting geology and mining, is not diminished by age, nor limited by its sphere of activity.

The increasing demands of trade upon nature's storehouse of useful minerals and the requirements of the State in their exploitation, exact increased watchfulness and care in all mining operations.

Located as the Society is, in the midst of a valuable coal-field, in one of the world's hives of industry, the Coal Measures come in for a large share of the attention of the members.

The great depths from which coal and other minerals are now successfully won demand the application of the best mechanical skill and the possession of the highest scientific attainments.

As the difficulties of the extraction of coal increase, by reason of the depth and other physical obstacles, so must coal-getting be a tributary to science and not a haphazard groping in the bowels of the earth.

The diffusion of this scientific knowledge among its members is the high aim and province of the Society.

The Report, having been duly moved and seconded, was unanimously approved and adopted by the meeting, the Chairman remarking that it was a very satisfactory one.

The Treasurer's Balance Sheet not being ready for the meeting, only a summary was presented, showing a balance in favour of the Society of £25 13s. 8d.

(The Balance Sheet, having since been sent in to the Hon. Secretary, is herewith appended.)

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MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET.

Dr.

1892-3. Abstract of Receipts.	£	s.	d.
Oct. 1.—To Balance brought down	205	13	2
,, Bank Interest	1	15	10
,, Do. do.	1	4	9
,, Birkenhead Dividend	11	14	0
,, Do. do.	11	13	6
,, Lancashire and Yorkshire Dividend	7	16	0
,, Do. do. do.	7	15	8
,, Transactions Sold	6	14	0
,, Subscriptions and Arrears	185	0	0
,, New Members—Half-year	1	10	0
	£440	16	11

Cr.

1892-3. Abstract of Payments.	£	s.	d.
By Library	25	0	8
,, Transactions	90	12	11
,, Reporters	11	11	0
,, Circulars and Stationery	8	7	0
,, Postages	29	3	2
,, Extra Meeting	0	19	6
,, Collectors' Commission	9	5	6
,, Rent, &c., to Literary Society	30	0	0
,, Insurance	0	12	6
,, Writing up Additions to Library	5	0	0
,, Attendance (C. Hargreaves)	5	0	0
,, Do. from last year	1	5	0
,, Elias Hall's Lancashire Map	2	0	0
	£218	17	3
,, Balance carried forward*	221	19	8
	£440	16	11

The Investments consist of £600 Four per Cent. Guaranteed Stock of the Birkenhead Railway, and £400 Lancashire and Yorkshire Consolidated Preference Stock in the names of Henry Mere Ormerod and Clegg Livesey.

1st October, 1893.

HENRY M. ORMEROD, Treasurer.

** This Balance is reduced by £196 6s., cost of purchase of £150 Lancashire and Yorkshire Railway Preference Stock, but not paid for at date of the Annual Meeting.*

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LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1892-93.

1892.

November. De Rance, C.E. "On the Glacial Drifts of Lancashire and Cheshire."

Stirrup, Mark. "Discovery of a large Boulder at Ardwick."

Zeiller, R. "On the Fossil Plants of the Dover Coal." (*Translation by Mark Stirrup.*)

Stirrup, Mark. "Report of the Delegate to the Meeting of the British Association at Edinburgh, August, 1892."

Clay, Stirrup, and Wild. "Globular Concretions from the Coal-Measures of Lancashire."

December. Gresley, W. S. "Reply to Discussion on a Typical Section of the 'Main' Coal of the Moira Division of the Leicestershire Coal-field."

De Rance, C.E. "On the Relation of Geology to the Population and Agriculture of England and Wales."

Grundy, James. "How and What to Observe in and about Mines, with some practical Tests."

1893.

January. Johnson, Isaiah. "The Substitution of Steel and Iron for Timber in Mines."

Hall, Henry. "Mis-Shots in Mines."

Dawkins, Prof. W. Boyd. "The Coalfields of New South Wales." (*Given at the Owens College.*)

February. Bell, Thomas. "Section of Strata in No. 2 Shaft, Deaf Hill Colliery, County Durham."

Traquair, Dr. R. H. "Notes on the Fossil Fish of the Marl Slate."

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1893.

February. Hull, Prof. Edward. "The Earthquake Shocks of 17th August, 1892, in the British Isles, and in Central France a week later."

Stainier, X. "Temperature Observations in a Deep Coal-Pit Sinking in Belgium, with analysis and temperature of a Spring of Water at a depth of 3,773 feet." (*Translation by Mark Stirrup.*)

Roeder, Charles. "List of Shells from the Lower Boulder Clay at Heaton Mersey, near Manchester, with Remarks thereon."

March. Caldwell, George. "Fossil Plants from the Cannel of the Wigan Four-Feet Mine."

Tonge, James. "On the Deepening of a Shaft at Hulton Colliery, Lancashire."

Wild, George. "Method and Value of Fossil Collection in Coal Mining."

Stirrup, Mark. "On some Recent Estimates of the World's Coal Supply."

April. Pickup, P.W. "Fossils from the Lower Coal-Measures."

Dickinson, Joseph. "On Outbursts of Soft Coal and Gas in the Royley Seam, Broad Oak Colliery, Ashton-under-Lyne."

May. De Rance, C.E. "On the Results of the Salt Union Boring, at Marston, near Northwich."

Grundy, Thomas. "On the Deepening of a Shaft under the Cages at Wigan Junction Colliery."

June. Stirrup, Mark. "Further Notes on Boulders from the Coal-Measures."

Lupton, Arnold. "On Mr. Dickinson's paper, 'Outbursts of Soft Coal and Gas in the Royley Seam.'"

Hollingworth, G. H. "The Outbursts at Nook Pit, Broad Oak Colliery."

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NEW ORDINARY MEMBERS.

Boyd, Alexander C.
Brown, John
Dutton, Frank
Fairhurst, John Thomas
Grant, Frederick John
Halliwell, James
Heyes, William A.
Holden, Arthur T.
Horrobin, Thomas
House, John
Laithwaite, V. W.
Mathews, D. H. F.
Matthews, E. L.
Millington, W. W.
Morris, M.
Rigby, John
Ross, Arthur
Smith Henry
Thom, John
Thompson, James
Thompson, Peter
Ward, Alexander H.
Warburton, Thomas

MEMBERS DECEASED.

Bryham, William
Burnett, R. T.
Derby, Earl of
Hewitt, John R.
Jamieson, Walter
Owen, Sir Richard
Peace, Maskell William
Speakman, John
Statter, Thomas.

MEMBERS RESIGNED.

Birtwistle, Arthur
Goodwin, Joseph
Roeder, Charles
Webster, Alfred E.

MEMBERS REMOVED FROM THE LIST.

Brown, William S.
Knowles, Israel
Morris, Thomas
Sixsmith, John
Taylor, John

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ELECTION OF OFFICERS.

The Hon. Secretary said the Council have, in accordance with the usual custom, proposed for nomination to the various offices certain gentlemen whom they consider the most suitable to fill them. I hold the list in my hand, and shall be pleased to read it to the meeting, but if any member has any other name to propose, it will of course be submitted along with these.

The nominations to the various offices were as follow :—

President:

WILLIAM SAINT, H.M.I.M.

Vice-Presidents:

JAMES GRUNDY, H.M.I.M.
GEORGE PEACE.
WILLIAM WATTS, F.G.S.
ROBERT WINSTANLEY.

Hon. Treasurer;

HENRY MERE ORMEROD, F.G.S.

Hon. Secretary:

MARK STIRRUP, F.G.S.

Members of the Council:

RICHARD CLAY.
CHARLES COCKSON.
JOSEPH CRANKSHAW.
SAMPSON GARSIDE.
JOHN GERRARD, H.M.I.M.
W. J. GREENER.
G. H. HOLLINGWORTH, F.G.S.
CLEGG LIVESEY.
ALFRED PILKINGTON.
HARRY SPEAKMAN.
GEORGE WILD.
H. A. WOODWARD.

Hon. Auditors:

CLEGG LIVESEY. | JAMES TONGE, F.G.S.

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The CHAIRMAN asked if any member had any other name to submit, and there being no response the gentlemen nominated by the Council were declared unanimously elected.

Mr. STIRRUP: It will be known, of course, to the members that we have a number of *ex-officio* Vice-Presidents who are permanent members of the Council. Amongst these are Mr. James Heywood, F.R.S., who took a great interest in the Society in its earlier years; Mr. G. C. Greenwell, Mr. Clifford Smith, Mr. H. M. Ormerod, the Earl of Crawford and Balcarres, Sir Ughtred Kay Shuttleworth, Mr. George Gilroy, Mr. Edward Pilkington, Professor Boyd Dawkins, Mr. Joseph Dickinson, Mr. John Knowles, Mr. Henry Hall, H.M. Inspector of Mines, Mr. John S. Burrows, and Mr. James Tonge. These gentlemen are permanent members of the Council. They have attained that position by reason of their having been in past years Presidents and active members of the Council.

This completed the business of the Annual Meeting, after which the Election of New Members was proceeded with.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary members of the Society:—

F. W. THOMPSON, Engineer and Surveyor, 5, Wood Street, Bolton.

JOHN P. KENRICK, Civil and Mining Engineer, 8, St. James's Square, Manchester.

ROBERT E. BANCROFT, Civil and Mining Engineer, 8, St. James's Square, Manchester.

ARTHUR TIMMINS, A.M.I.C.E., F.G.S., Bridgewater Foundry, Runcorn.

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The receipt of a syllabus was announced from the South Kensington Museum of a course of twelve Swiney Lectures, during the month of October, on the "Bearings of Geology on the Distribution of Animals and Plants"; also one of a series of Monday Evening Popular Lectures at the Owens College during the ensuing winter session.

Mr. STIRRUP read the following letter from the author, one of the members of the Society, *re* "Guide to the Mining Laws of the World":—

2, Stone Buildings, Lincoln's Inn,
3rd October, 1893.

To M. STIRRUP, Esq., Hon. Secretary of the Manchester Geological Society.

Dear Sir,

Availing myself of your kind offer, I now ask you to bring before the notice of the members of your Society the book which I am about to publish under the title of a "Guide to the Mining Laws of the World," which, I trust, may be of interest to them, not only on account of the subject, but also because I may say that the publication of the book has indirectly resulted from the fact of my being a member of your Society. The preparation of a paper which I read at a meeting of the Society in 1888, in reply to Mr. C. M. Percy's paper on "Mine Rents and Royalties," first led me to inquire into the subject which I have now dealt with in my book, and which I then found had not been comprehensively dealt with in the English language. The non-existence of such a book in the English language was somewhat strange, as in other countries—such as France and Italy—which cannot be so extensively concerned in mining enterprises as England or the United States of America, the subject seems to have been considered worthy of elaborate treatises. Subsequently, I had occasion to inquire more fully into the subject in connection with the recent Royal Commission on Mining Royalties, to which I had the honour of furnishing information with regard to it in evidence. Since that date I have extended my inquiries considerably beyond the area which was necessary to be considered for the purpose of the Royal Commission, and I have had the good fortune to meet with materials which have enabled me to deal with the subject on a wider scale than has, I believe, been attempted even in any of the foreign treatises before alluded to; and I have endeavoured to deal with my

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materials in such a way as will be calculated to render the book a simple but exhaustive guide to persons who, for practical or theoretical purposes, may wish to gain an insight into the principles and details of mining legislation in the different countries of the world.

In the arrangement of the book I have endeavoured to treat of all countries in which the mining industry is of any considerable importance in the order to some degree of their values from a mineral point of view. I have endeavoured in all cases to obtain the most recent information, and although in some foreign countries, and even in some of our own colonies, legislation is so "fast and furious" that it is almost impossible to keep up to date in reference to all details of laws and regulations, still it is so clearly the fact that the general principles of mining laws in different countries, like the customs of particular mining districts in each country, are slow to change, that the information as to general principles stated in the book may in all cases, I think, be relied upon as absolutely accurate. A list of the countries treated of in the book is given in the Index, a copy of which is attached to the prospectus, of which I send you some copies (and of which a copy shall be forwarded by post to each of the members of your Society), from which I venture to think it will be seen that the countries dealt with—ranging from Great Britain to Japan—are so widely distributed throughout the world as to justify the somewhat ambitious title of the book.

In dealing with each particular country, I have endeavoured to supply particulars as to the history of the legislation, as to the principles obtaining with regard to property in minerals, as to taxation or other burdens thereon, and as to the rights and liabilities of the various parties interested therein; followed in some cases by general observations upon the actual operation of and alterations where proposed in the law; at the same time I have carefully avoided the expression of any personal views which I may have put forward before your Society or otherwise, as I am most anxious and indeed trust that the book will be found to be an absolutely independent and accurate record of facts; and I must leave it to others, should they think it desirable, to comment upon and draw conclusions from the facts which I have thus been enabled to present for their consideration.

With many thanks for your kindness in offering to bring the book before the notice of your Society,

Believe me, yours truly,

OSWALD WALMESLEY.

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Mr. Stirrup afterwards drew attention to a Geological Map of Russia in Europe, recently presented by the Geological Committee, Institute of Mines, St. Petersburg.

It is in six sheets, on a scale of 1 : 2,520,000, and is the first map of the European portion of the Empire of Russia which can claim to give a detailed and correct description of the geology of this vast area, although there are still two vast regions in the North of Russia whose solid geology is for the most part unexplored, viz., the marshy plain of Bolschézemelié and the region dividing the rivers Vytchegda, the Mezen, the Pinega, and the Dvina.

Nearly the whole of Russia in Europe, as is well known, is covered by post-tertiary deposits—alluvial, lacustrine, glacial, &c.—but this map presents the underlying rock formations, which are indicated by forty-five different signs and with a nearly equal number of tints of colour, thus giving a clear idea of the geological constitution of the country.

With regard to the programme for the coming session Mr. Stirrup said a paper had been promised by Professor Boyd Dawkins; and they would also have an account of the boring in search of coal at Hazel Grove, on the estate of the Freeholders' Company, from Mr. De Rance. This paper, he was sure, would be of great interest, not only to the gentlemen immediately concerned, but also to the public at large. A paper had also been promised by Mr. Kinahan, late of the Irish Geological Survey, on the iron ores of Antrim; and two or three other members had promised contributions. The Wigan meetings, he hoped, would be supplied with interesting material for discussion by members in that locality.

The Chairman remarked that it was a very good list to begin with.

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APPENDIX TO THE REPORT.

PRESENTATIONS TO THE LIBRARY, 1892-93.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers.—Proceedings. Part 114, Vol. XIII.; and Parts 118-19, Vol. XIII. *From the Institute.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1891-92. *From the Society.*

Bradford.—Twenty-second Annual Report of Free Libraries for 1892.

Bristol.—Naturalists' Society.—Proceedings. Part 2, Vol. VII. *From the Society.*

Cambridge.—Additions to Type Fossils in the Woodwardian Museum. Extract (Pamphlet form) from Geological Magazine, Vol. X., Decade 3, No. 345; 27th Annual Report Museums and Lecture Rooms' Syndicate for 1892. *From Woodwardian Museum.*

Cardiff Natural History Society.—Report and Transactions. Part 2, Vol. XXIV. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Annual Report, 1892; also Transactions, Part 7, Vol. XVII. *From the Institute.*

Camborne.—Mining Institute and Association of Cornwall.—Transactions. Parts 1-2, Vol. III.; and Part 1, Vol. IV. *From the Institute.*

Cornwall.—Royal Institution of.—Journal. 1890-91, Vol. X.; and No. 2. Vol. XI. *From the Institute.*

Dublin.—The Royal Dublin Society. Second series, Scientific Transactions. Vols. IX., X., XI., XII., XIII., for year 1891; also new series, Transactions, Parts 3-4, Vol. VII., 1892. *From the Society.*

Edinburgh.—Royal Society of.—Proceedings. Vol. XVIII., 1891-92. *From the Society.*

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Edinburgh Royal Physical Society.—Proceedings. Part 2, Vol. XI. *From the Society.*

Essex Naturalist.—Journal. Nos. 9-12, Vol. VI.; and Nos. 1-5, Vol. VII. *From the Essex Field Club.*

Glasgow.—Geological Society of.—Transactions. Part 2, Vol. IX. *From the Society.*

Glasgow.—Natural History Society of.—Proceedings and Transactions. New series, 1889-92, Part 3, Vol. III. *From the Society.*

Hamilton, Scotland.—Mining Institute of Scotland. Transactions. Parts 4-11, Vol. XIV.; and Part 1, Vol. XV. *From the Institute.*

Hertfordshire Natural History Society and Field Club. Transactions. Parts 8-9, Vol. VI.; and Parts 2-6, Vol. VII. *From the Society.*

Leeds Philosophical and Literary Society.—Annual Report for 1892-93. *From the Society.*

Leeds.—Yorkshire Naturalists' Union.—Transactions. Part 17, for 1891; and Part 18, for 1892. *From the Society.*

Leeds Geological Association.—Transactions for 1891-92. *From the Association.*

Leicester Literary and Philosophical Society.—Transactions. Part 12, Vol. II.; and Parts 1-2, Vol. III. *From the Society.*

Liverpool Science Students' Association.—Annual Reports and Proceedings, Sessions 1890-91 and 1891-92. *From the Association.*

Liverpool Geological Association.—Journal. Vol. XII. *From the Association.*

Liverpool Geological Society.—Proceedings. Index to Vol. VI.; also Part 1, Vol. VII.

London Royal Society.—Proceedings. Parts 314-315, Vol. LI.; Parts 316-320, Vol. LII.; Parts 321-325, Vol. LIII.; and Part 326, Vol. LIV. *From the Society.*

London Year Book of Scientific and Learned Societies of Great Britain and Ireland, 1893. *Purchased.*

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London Institute of Mechanical Engineers.—Proceedings. Nos. 3-4, for 1892, and Nos. 1 and 2 for 1893. *From the Institute.*

London Geological Society.—Quarterly Journal. Nos. 192, Vol. XLVIII.; and 193-195, Vol. XLIX. *From the Society.*

London Geologists' Association.—Proceedings. Parts 9-10, Vol. XII.; and Parts 1-5, Vol. XIII. *From the Association.*

London Geological Magazine.—Nos. 340-342, Vol. IX.; and Nos. 343-352, Vol. X. *Purchased.*

London Iron and Coal Trades Review.—Nos. 1285 and 1290, Vol. XLV.; and Nos. 1303 and 1311, Vol. XLVI. *From the Editor.*

London Iron and Steel Institute.—Special Vol. of Proceedings in America in 1890. Journal. Part 1, Vol. XLIII.; also Rules and List of Members. *From the Institute.*

London Palæontographical Society.—Monographs for 1892. *Purchased.*

Manchester.—Salford Royal Museum. Annual Report, 1891-1892. *From the Museum.*

Manchester Literary and Philosophical Society.—Memoirs and Proceedings. No. 2, Vol. V., 4th Series; Vol. VI., Dr. Joule, 4th Series; and Parts 1-3, Vol. VII., 4th Series. *From the Society.*

Manchester Geographical Society.—Journal. Nos. 10-12, Vol. VII.; Nos. 1-6, Vol. VIII.; and Nos. 1-6, Vol. IX. *From the Society.*

Manchester Association of Engineers.—Transactions, 1892. *From the Association.*

Manchester and Salford Sanitary Association.—Annual Report for 1892. *From the Association.*

Manchester Field Naturalists' Society.—Report and Proceedings for 1892. *From the Society.*

Manchester Owens College.—Calendar for Session 1893-1894. *From the College.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers.—Transactions. Part 3, Vol. XXXIX.; Part 5, Vol. XL.; Parts 5-6, Vol. XLI.; Parts

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1-4, Vol. XLII.; and Part I., Vol. XLIII.; also Annual Report, Accounts, &c., for 1892 and 1893. *From the Institute.*

Rochdale Literary and Scientific Society.—Transactions for 1891-1892, Vol. III. *From the Society.*

Stoke-on-Trent.—North Staffordshire Institute of Mining and Mechanical Engineers.—Proceedings. Parts 3-4, Vol. XI.; and Parts 1-3, Vol. XII.

Swansea.—South Wales Institute of Engineers.—Proceedings. Parts 1-3, Vol. XVIII. *From the Institute.*

Whitaker, W., B.A., F.G.S., The following Books and Pamphlets presented by:—

"Taconic System," and its position in Stratigraphic Geology. By Jules Marcou.

Unification des Procédés dans les Cartes Geologiques. 1882. By A. Heim.

Quebec Group in Geology. Address by A. R. C. Selwyn, LL.D., F.R.S., 1882.

Louisville Limestones, 1877. By James Hall.

Geological History of Serpentines and Studies of Pre-Cambrian Rocks, 1883. By Thomas Sterry Hunt, Montreal.

Taconic Question in Geology. Part 1, 1883. By Thomas Sterry Hunt, Montreal.

And sundry Pamphlets.

Annals of British Geology, 1891. By J. F. Blake, F.G.S. *Purchased.*

On the Organization of Fossil Plants of the Coal Measures, Part 19. By W. C. Williamson, LL.D., F.R.S. *From the Author.*

Report of British Association for the Advancement of Science. Edinburgh Meeting, August, 1892. *From the Association.*

Reports of H.M. Inspectors of Mines for 1892. *Presented by J. S. Martin, Esq.*

Science and Art of Mining, Parts 16 and 21, Vol. III.; also Parts 3-4, Vol. IV. *From the Editor.*

Reports on an Explosion at Park Slip Colliery, N.S.W. District, 26th September, 1892. By A. Young, J. P. Robson, and W. N. Atkinson. *Presented by W. N. Atkinson, Esq.*

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Mineralization of Minute Tissues of Animals and Plants. Address by W. C. Williamson, LL.D., F.R.S. Pamphlet. *From the Author.*

Twenty-third Annual Report of Committee of Tynemouth Free Library, for year ending December 31st, 1892. *From the Committee.*

Report for North Staffordshire District Mines, No. 10. *Presented by W. N. Atkinson, Esq.*

Some Recent Results of the Investigations into Local Erratic Blocks. Pamphlet. By S. S. Platt. *From the Author.*

Three Museum Handbooks, 1893 *From Owens College Museum, Manchester.*

Index to the Author's Collective Memoirs on Fossil Plants of Coal Measures, Part 2. By W. C. Williamson. *Presented by the Author.*

Geological History of the Rawdon and Boothorpe Faults in the Leicestershire Coal Fields. Pamphlet. By W. S. Gresley. *From the Author.*

Hints for Guidance of Observers of Glacial Geology. By P. F. Kendall, F.G.S., Stockport. *From the Glacialists' Association.*

Fossil Botany. By H. Graf zu Solms-Laubach. *Purchased.*

Physics of the Earth's Crust. Second edition. By Osmond Fisher. *Purchased.*

On the Causes of the Phenomena of Terrestrial Magnetism. *Presented by the Author, Henry Wilde, Esq., F.R.S.*

Reports, Mines, for South-Western District, No. 12, for 1892. By J. S. Martin, Esq., H.M.I.M. *Presented by J. S. Martin, Esq.*

Reports, Mines and Minerals. Mineral statistics of the United Kingdom, with Isle of Man, for 1892. By J. S. Martin, Esq., H.M.I.M. *Presented by J. S. Martin, Esq.*

Notes on the Use of Explosives in Coal Mines for 1892. By H. A. Krohn.

Aids in Practical Geology. By Prof. Grenville Cole. *Purchased.*

The following Works were presented by J. Gerrard, Esq.:—

List of Mines worked in the year 1892 (under different Regulation Acts. By J. Gerrard, Esq.

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Mineral Statistics of United Kingdom of Great Britain and Ireland with Isle of Man, for year 1892. By J. Gerrard, Esq.

List of Plans of Abandoned Mines deposited in the Home Office, corrected to December 31st, 1892. By J. Gerrard, Esq.

Summaries of Statistical portion of Reports of H.M. Inspectors of Mines, Lists of Inspectors, &c. By J. Gerrard, Esq.

Report by John Gerrard, Esq., for Manchester and Salford District No. 6, for year 1892.

INDIA.

Calcutta.—Records of the Geological Survey of India. Parts 3-4, Vol. XXV., also Parts 1-3, Vol. XXVI.; and Handbooks of Commercial Products, *Iron*, No. 8. *From the Governor General in Council.*

AUSTRALIA.

Adelaide.—Royal Society of South Australia.—Transactions, Part 2, Vol. XV.; Parts 1-2, Vol. XVI.; and Part 1, Vol. XVII. *From the Society.*

Brisbane.—Queensland Museum.—Annual Report for 1892. *Presented by the Trustees.*

Melbourne.—Geological Society of Australasia.—Transactions, Part 6, Vol. I. *From the Society.*

Sydney.—The Australian Mining Standard: A Record of Mining, Financial, and Engineering Progress, Nos. 199-216, Vol. VIII.; also Nos. 217-253, Vol. IX. *From the Editor.*

Sydney.—Geological Survey of New South Wales: Department of Mines. Records, Parts 1-3, Vol. III.; also Index to Vol. II.; and Palæontology, No. 5; Annual Report Department of Mines and Agriculture, New South Wales for 1892. *From the Hon. the Minister of Mines.*

Sydney.—Royal Society of New South Wales.—Journal and Proceedings, Vol. XXVI. *From the Society.*

Sydney.—Australian Museum.—Report of Trustees for 1891 and 1892.

Wellington.—Mining Industry Report of New Zealand for 1892.

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Canada.

Halifax, N.S.—Nova Scotian Institute of Science.—Proceedings and Transactions. Part 2, Vol. I. 2nd series. *From the Institute.*

Halifax, N.S.—Mining Society of Nova Scotia.—Transactions. Parts 2-3, Vol. I. *From the Society.*

Hamilton Association.—Journal and Proceedings. No. 9, Session 1892-93. *From the Association.*

Ottawa.—Canadian Mining Review, Nos. 9-12, Vol. XI.; and Nos. 1-9, Vol. XII. *From the Editor.*

Ottawa.—Geological and Natural History Survey of Canada. Contributions to Canadian Palæontology. By J. F. Whiteaves. *From Director of Survey.*

Saint John, New Brunswick.—Natural History Society of New Brunswick.—Bulletin 10. *From the Society.*

Toronto.—Canadian Institute.—Transactions. No. 5, Part 1, Vol. III. *From the Institute.*

U.S. America.

Cambridge.—Harvard College.—Bulletin of the Museum of Camparative Zoology. Nos. 5-6, Vol. XXIII.; Nos. 1-7, Vol. XXIV.; and No. 1, Vol. XXV.; also Annual Report for 1891-92, and Nos. 11-14, Vol. XVI., Geological Series; and No. 54, Vol. VII., and No. 2, Vol. II. *From A. Agassiz.*

Chapel Hill, North Carolina.—Elisha Mitchell Scientific Society.—Journal. Parts 1-2, Vol. IX. *From the Society.*

Denver.—Colorado Scientific Society.—On the Post-Laramie of Middle Park (Col.), 1892; also a Volumetric Method for the Determination of Lead. Production of Columbous and Tungstous Oxides in forming Compounds of Iron and Tin. By William P. Headden. Pamphlet. The Latest Method of Electric Car Control. By Irvine Hale. Pamphlet. A Review of the Russell Process. By L. D. Godshall. Pamphlet. On a Series of Peculiar Schists, near Salida, Colorado. By Whitman Cross. Pamphlet. Certain Dissimilar Occurrences of Gold-bearing Quartz. By T. A. Rickard. Pamphlet. *From the Society.*

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Indianopolis.—Geological Survey of Indiana. Eighteenth Report, September, 1892. *From the Survey.*

Michigan Mining School.—Catalogue, 1891-92; also Reports of the Director of the Michigan Mining School for 1890-92. *From the School.*

Milwaukee.—City of Milwaukee Public Museum.—Tenth Annual Report. September 1st, 1892, to August 31st, 1892. *From the Board of Trustees.*

Minneapolis.—The American Geologist.—Nos. 4-6, Vol. X.; Nos. 1-6, Vol. XI.; and Nos. 1-3, Vol. XII. *Purchased.*

Minneapolis.—Geological and Natural History Survey of Minnesota.—Nineteenth Annual Report for 1890-91; Bulletin No. 7; Mammals of Minnesota, by C. L. Herrick; and Bulletin No. 8, 1893. *From the Survey.*

New York.—American Institute of Mining Engineers.—Transactions. Vol. XX. and XXI. *From the Institute.*

New York.—The American Museum of Natural History.—Bulletin, Vol. IV.; also Annual Report for 1892. *From the Museum.*

Philadelphia.—Franklin Institute.—Journal. Nos. 802-804, Vol. CXXXIV.; Nos. 805-810, Vol. CXXXV.; and Nos. 811-14, Vol. CXXXVI. *From the Institute.*

Philadelphia.—Academy of Natural Sciences.—Proceedings. Part 1, January-March, 1893. *From the Academy.*

Philadelphia —American Institute of Mining Engineers.---List of Officers, Members, Rules, &c., 1893. *From the Institute.*

Report of Commission on Waste of Coal Anthracite Mining.—Philadelphia, May, 1893.

U.S.A., Scranton, Pa.—The Colliery Engineer. Journal. Nos. 3-12, Vol. XIII.; and Nos. 1-3, Vol. XIV. *From the Editor.*

Springfield, Ill.—Illinois Mining Institute. Journal. Vol. I. *From the Institute.*

Washington.—United States Geological Survey.—Mineral Resources of United States for 1889-90. Bulletins No. 82-83, 1891; Nos. 84-86, and Nos. 90-96, 1892. Monographs, Vols. XVII.,

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XVIII., and XX., 1892. Atlas, to accompany the Monograph of the Geology of the Eureka district of Nevada. By Arnold Hague. Mineral Resources of U.S. for year 1891; also Eleventh Annual Report. Part 1, Geology; Part 2, Irrigation. *From the Director of Survey.*

Washington.—Smithsonian Institution.—Report for the year ending June 30th, 1890. *From the Board of Regents.*

Wisconsin Academy.—Transactions, &c., Vols. II.-VIII., from 1873 to 1891. *From the Academy.*

The following Pamphlets presented by the author, Lewis Woolman, viz.:—

Artesian Wells and Water Horizons in Southern New Jersey.

Artesian Wells, Atlantic City, New Jersey.

Geology of Artesian Wells at Atlantic City, New Jersey.

A Review of Artesian Horizons in Southern New Jersey.

FOREIGN.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, Nos. 2-6, Vol. XXVII., and No. 1, Vol. XXVIII.; Verhandlungen, Nos. 6-10, Vol. XIX., and Nos. 1-7, Vol. XX.—*From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft, Heft 3-4, Vol. XLIV.; Heft 1, Vol. XLV.—*From the Society.*

Brussels.—Société Royale Malacologique de Belgique.—Annales, Vol. XXVI., 1890; also Vol. XV., 1880, Part 2; Procés-Verbaux, Vol. XXI., Part 4, 1892; Catalogue Illustré des Coquilles Fossiles, 1893. *From the Society.*

Dresden.—Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis, 1891 and 1892; also January to June, 1889. *From the Society.*

Freiburg in Baden.—Berichte der Naturforschenden Gesellschaft, Heft 1-4, Vol. VI. *From the Society.*

Halle A/s.—Verein für Erdkunde.—Mittheilungen, 1892. *From the Society.*

Kazan.—Russia.—La Société des Naturalistes de l'Université de Kazan: Part 6, Vol. XXIII.; Parts 1-5, Vol. XXIV.; Proceedings, 1891-2; Proceedings, 5 parts, comprising 20-30, 1893. *From the Society.*

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Kieff.—Russia.—Memoires de la Société des Naturalistes de Kieff, Parts 1-2, Vol. XII. *From the Society.*

Lausanne.—Bulletin de la Société Vaudoise des Sciences Naturelles: Nos. 108-109, Vol. XXVIII., and Nos. 110-112, Vol. XXIX. *From the Society.*

Lille.—Société Géologique du Nord —Annales, 17, 18, 19, and 20, for years 1889-90 to 1892. *From the Society.*

Mexico.—Memorias Y. Revista de la Sociedad Cientifica "Antonio Alzate," Nos. 11-12, Vol. V.; and Nos. 1-10, Vol. VI.; Sinopsis Mineralogica, by C. F. de Landero. *From the Society.*

Naples.—Rendiconto dell' Accademia della Scienze fisiche Mathematische, Series 2, Nos. 7-12 and 1-2, Vol. VI., and Nos. 3-7, Vol. VII. *From the Academy.*

Paris.—Annuaire Géologique Universel. Parts 2-4, Vol VIII.; also Part 1, Vol. IX. *From Dr. L. Carez.*

Paris.—Subterranean Explorations, various Pamphlets, 1892. By M. E. A. Martel. *From the Author.*

Pisa.—Atti della Societa Toscana di Scienze Naturali. Processi Verbali, Vol. VIII.; also Memorie, Vol. XII. *From the Society.*

Roma.—Atti della Reale Accademia die Lincei: Rendiconti, Fascs 4-8, 10, 11, 12, Vol. I., and Fascs 1-12, Vol. II., first series; also Fascs 1-6, Vol. 2, second series. *From the Academy.*

St. Petersburg.—Académie Impériale des Sciences de St. Petersburg: Mémoires, No. 9-14, Vol. XXXVIII., and No. 1, Vol. XL. *From the Academy.*

St. Petersburg.—Kaiserliche Mineralogische Gesellschaft: Verhandlungen, Vol. XXVIII., 1891. *From the Society.*

Stuttgart.—Separat-Abdruck aus Palæontographica: Vol. XXXIX. *Presented by C. Roeder, Esq.*

BOOKS PURCHASED.

Fossil Botany. Solms-Laubach.
Explosives and their Power. Berthelot.
Text-Book of Coal Mining. H. W. Hughes.
Physics of the Earth's Crust. O. Fisher.
Aids in Practical Geology. G. Cole.

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Annals of British Geology, 1891. Professor Blake.
American Geologist. (Monthly.)
Geological Magazine. (Monthly.)
Palæontographical Society. Vol. XLVI., 1892.
Official Year Book of Scientific and Learned Societies, 1892.

Societies with which the Society Exchanges its Transactions, and Institutions and Journals to which a Copy is sent free.

I.—England.

London ..... British Museum
British Museum Library, Natural History Department, Cromwell Road, South Kensington.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologist's Association, University College, Gower Street, W.C.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute, Victoria Mansions, S.W.
Royal Institution of Great Britain, Albemarle Street, Piccadilly, W.
Royal Society, Burlington House, W.
Public Library, Kensington, High Street, W.

Manchester ..... The Manchester Association of Engineers.
Field Naturalists' Society, 16, Kennedy Street.
Free Library, King Street.
Literary and Philosophical Society, 36, George Street.
Manchester Geographical Society, 44, Brown Street.
The Manchester Museum, Owens College.
The Library, Owens College.
Salford Royal Museum and Library.

Barnsley ..... Midland Institute of Mining Engineers.

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Birmingham .....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol.....Naturalists' Society, Ashgrove House, 145, Whiteladies Road (C. K. Rudge, M.R.C.S.)

Cambridge .....Geological Museum, University.
University Library.

Cardiff.....Cardiff Naturalists' Society, 44, Loudoun Square.

Chester.....Society of Natural Science, Grosvenor Museum.

Chesterfield .....Institution of Mining Engineers, 13, Cavendish Street.

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.

Tuckingmill, Camborne.... } Mining Association and Institute of Cornwall.

Essex ..... { Essex Field Club (A. P. Wire, Hon. Librarian, 1, Seaton Villas, Birkbeck Road, Leytonstone, London, E.

Exeter .....Albert Memorial Museum.

Halifax .....Geological and Polytechnic Society of Yorkshire.

Leeds .....Philosophical and Literary Society.
Geological Association, Mechanics Institution, Cookridge Street.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Sunny Bank).

Leicester .....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society, Royal Institution.
Science Students' Association, Royal Institution, Colquitt Street.

Newcastle-on-Tyne .North of England Institute of Mining and Mechanical Engineers.

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Newcastle, Staffordshire .... North Staffordshire Naturalists' Field Club (Rev. T. W. Daltry, M.A., F.G.S., Madeley Vicarage).

Norwich .....Geological Society, The Museum.

Oxford ... .Bodleian Library.
Radcliffe Library.

North Shields ....Public Free Library.

Rochdale .....Rochdale Literary and Scientific Society, 20, King Street South, Rochdale.

Southampton ....Hampshire Field Club, Hartley Institution.

Stoke-on-Trent ...North Staffordshire Institute of Mining and Mechanical Engineers.

Swansea .....South Wales Institute of Mining and Mechanical Engineers.

Warwick .....Natural History Society.

Watford, Herts ..Hertfordshire Natural History Society and Field Club, the Public Library, Watford.

Wigan ....Free Library.
Mining School.

II.—Scotland.

Dundee ..... .Free Library and Museum.

Edinburgh .....Advocates' Library.
Geological Society, 5, St. Andrew Square.
Royal Society.
Royal Physical Society, 18, George Street.

Glasgow .....Geological Society, 207, Bath Street.
Natural History Society.

Hamilton .....Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.

Belfast ... .Natural History Society, the Museum.

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IV.—Australia.

Melbourne . . . . . Geological Society of Australasia, 17A, Queen Street.

Public Library of Victoria.

Sydney . . . . . Free Public Library.

Royal Society of New South Wales, 37, Elizabeth Street.

Department of Mines.—The Honourable the Minister of Mines.

Australian Mining Standard, 108, Pitt Street.

V.—Canada.

Hamilton . . . . . Hamilton Association.

Ottawa . . . . . Geological and Natural History Survey of Canada (A. R. C. Selwyn, F.G.S, Director, Museum, Sussex Street, Ottawa).

M'Gill College (Principal, Sir J. W. Dawson, F.G.S.).

Editor of Canadian Mining Review.

Toronto . . . . . Canadian Institute.

Halifax, Nova Scotia . . } Nova Scotian Institute of Natural Science.

St. John, N.B. . . . . Natural History Society of New Brunswick.

VI.—United States.

Boston, U.S. . . . . . Free Library.

Chapel Hill, North Carolina, U.S. } The Elisha Mitchell Scientific Society.

Columbus, U.S. . . . . Geological Survey of Ohio (Professor Edward Orton, State Geologist).

Denver . . . . . Colorado Scientific Society, Denver, Colorado.

Indianopolis, Indiana, U.S. } Department of Geology and Natural History. S. S. Gorby, State Geologist.

Madison, Wisconsin . . } Wisconsin Academy of Sciences, Arts, and Letters.

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Newhaven, U.S. ..Professor O. C. Marsh, F.G.S.

New York, U.S. ..American Institute of Mining Engineers (R. W. Raymond, Box 223, New York City).

New York .....American Museum of Natural History, Seventy-seventh Street, and Eighth Avenue.

Philadelphia, U.S...Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104 S Fifth Street.

Scranton, Pa. ....Editor of the Colliery Engineer.

Springfield, Ill....Illinois Mining Institute.

Washington, U.S...Department of the Interior. U.S. Geological Survey.
Smithsonian Institution.

Wyoming, U.S....Historical and Geological Society.

VII.—Foreign Societies.

Berlin ....Deutsche Geologische Gesellschaft.
Gesellschaft für Erdkunde. Zimmerstrasse, 90, Berlin, S.W., 12.

Brussels ....Société Royale Malacologique de Belgique.

Buenos Ayres ....Officiana Nacional de Commercie.

Caen, Calvados, France ..... } Société Linnéenne de Normandie.

Calcutta .....Geological Survey of India.

Christiana .....Royal University of Norway.

Dresden . .. ...Naturwissenschaftliche Gesellschaft Isis.

Freiburg in Baden..Naturforschende Gesellschaft (Dr. V. Häcker, Secretary).

Halle, A.S......Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

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Kazan, Russia....La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia.....La Société des Naturalistes.

Lausanne (Suisse)..Société Vaudoise des Sciences Naturelles.

Iglo, Hungary....Société Hongroise de Carpathes (Centrale in Leutschau).

Lille.....Société Géologique du Nord.

Mexico.....Sociedad Cientifica "Antonio Alzate."

Naples.....Royal Academy of Sciences, Bibliothèque de l'Université de Naples.

Paris.....Annuaire Géologique Universel (Dr. L. Carez, 36, Avenue Hoche, Paris.

Pisa.....Società Toscani di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro....Museo Nacional.

Rome.....Reale Accademia dei Lincei.

St. Petersburg....Académie Impériale des Sciences.
Institut des Mines. Comitè Géologique.

Turin.....Acadêmie Royale des Sciences.

VIII.—Scientific Journals, &c.

Iron and Coal Trades Review, 342, Strand, W.C.

Geological Record, W. Topley, F.G.S., Museum, Jermyn Street, London, S.W.

Mining Journal, 18, Finch Lane, London, E.C.

Colliery Guardian, 49, Essex Street, Strand, London.

The Science and Art of Mining, 27, Wallgate, Wigan.

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PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Moseley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-4	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1878-9	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-1	Kay-Shuttleworth, Sir Ughtred J., Bart.
1881-2	Gilroy, George, M.Inst.C.E.
1883-4	Pilkington, Edward, J.P.
1885-6	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.

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LIST OF MEMBERS.

OCTOBER, 1893.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Colliery Offices, Walkden, Bolton.
1884	Aldred, James, Withings Lane Colliery, Radcliffe.
1879	Arrandale, John Thomas, The Grange, Coppull, near Chorley.
1878	Ashworth, Thomas, 28, Deansgate, Manchester.
1877	Atherton, James, 24, Mawdsley Street, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Newcastle, Staffordshire.
1881	Aubrey, Richard Charles, The Midland Coal, Coke, and Iron Co., Ltd., Halmerend, near Newcastle, Staffordshire.
1893	Bancroft, Robert Ed., 8, St. James's Square, Manchester.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1880	Barton, Richard.
1889	Beck, William, Ellerbeck Collieries, near Chorley, Lancashire.
1891	*Bell, Thomas*, H.M. Inspector of Mines, Shamrock House, Durham.
1881	Black, W. G., F.R.C.S.Ed., F.G.S.Ed., 2, George's Square, Edinburgh.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., Baxenden, Accrington.
1887	Boole, George, Rainford Colliery, near St. Helens.
1892	Boyd, Alexander C., The Lakes, Dukinfield.

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Year of Election.	
1878	Bradford, The Right Hon. the Earl of, Bradford Estate Office, Bolton (G. R. Carter, Esq., Agent).
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester.
1891	Bramhall, Ernest E., Radcliffe Collieries, near Manchester.
1878	Brocklehurst, Thomas, Rumworth Colliery, Dean, Bolton.
1877	*Broeck, Ernest Van den*, 39, Place de l'Industrie, Brussels.
1877	*Brongniart, Charles*, F.E.S., 9, Rue Linné, Paris.
1893	Brown, John, Ringley Fold, Stoneclough, near Manchester.
1881	Bryham, William, Douglas Bank Colliery, Wigan.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., F.G.S., Yew Tree House, Atherton, near Manchester. *Past-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan.
1884	Campbell, H. H., Surveyor, Hardshaw Street, St. Helens.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1881	Clark, Christopher F., Park Lane Collieries, Wigan.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1889	Clay, Richard, Dukinfield Coal Company, Dukinfield. *Member of Council.*
1886	Clifford, William, 610, Lewis Block, Pittsburg, Pa., U.S.A.
1882	Cockson, Charles, King Street, Wigan. *Member of Council.*
1878	Cowburn, Henry, 253, West Leigh Lane, West Leigh, near Manchester.
1883	Crankshaw, Joseph, Montcliffe Colliery, Horwich. *Member of Council.*
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A., The Owens College, Manchester. *Past-President.*
1877	*De Rance, C.E.*, F.G.S., Alderley Edge, near Manchester.

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Year of Election.	
1890	Dean, John, Wigan Coal and Iron Co., Limited, Wigan.
1856	Dickinson, Joseph, F.G.S., South Bank, Pendleton. *Past-President.*
1889	Dobbs, Joseph, Coolbawn, Castlecomer, Co. Kilkenny.
1891	Dobb, Thomas G., Colliery Manager, Hindley, Wigan.
1891	Dodds, James, Crooklands, Lymm, Cheshire.
1892	Dutton, Frank, Crown Street, Bolton.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1878	Ellesmere, The Right Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1891	Fallows, William, Arbury Road, Nuneaton.
1880	Fairclough, William, Leigh, near Manchester.
1893	Fairhurst, John Thomas, Penfall Colliery, Haydock, near St. Helens.
1891	Finch, John, Ashton Moss Colliery, Audenshaw, near Manchester.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe.
1873	Fletcher, Herbert, The Hollies, Bolton.
1875	Fletcher, Ralph, Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1889	Foster, John W., 24, Silksworth Terrace, New Silksworth, Sunderland.
1873	Garforth, W. E., F.G.S., Halesfield, Normanton.
1884	Garside, Sampson, Denton and Haughton Collieries, Denton. *Member of Council.*
1892	Gerrard, John, H.M. Inspector of Mines, Worsley. *Member of Council.*
1889	Gascoyne, Rowland, Brackburn Collieries, Broxburg, near Johannisburg, South African Republic.

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Year of Election.	
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1856	Gilroy, George, M.Inst.C.E., Mayfield, Orrell Post, near Wigan. *Past-President.*
1882	Glover, B. B., Newton-le-Willows.
1892	Grammer, F., 10, Egerton Terrace, Stockport Road, Ardwick.
1892	Grant, Frederick John, Bank Field, Burnley.
1890	Green, John, the Hanley Colliery Co., Limited, Stoke-upon-Trent.
1878	Greener, W. J., Pemberton Colliery, Wigan. *Member of Council.*
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1863	Greenwell, G. C., F.G.S., Elm Tree Lodge, Duffield, Derby. *Past-President.*
1890	Gresley, W. S., F.G.S., P.O. Box 437, Erie, Pennsylvania, U.S.A.
1874	Greenwell, G. C., jun., F.G.S., Poynton, near Stockport.
1879	Greenwood, John, 71, Dickinson Road, Rusholme, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1883	Greensmith T., Moston Colliery, Failsworth, Manchester.
1888	Grundy, James, H.M. Inspector of Mines, 39, Victoria Terrace, Manchester Road, Bolton. *Vice-President.*
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1890	Grundy, Thomas, Wigan Junction Colliery, Abram, near Wigan.
1889	Hacking, James, Bolton Road, Darwen.
1887	Hallas, Geo. H., Wigan and Whiston Coal Company, Ltd., Prescot.
1892	Halliwell, James, Duxbury Park Colliery, Chorley, Lancashire.
1890	Haines, J. Richard, F.G.S., Adderley Green Collieries, near Longton, Stoke-on-Trent.

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Year of Election.	
1883	Hall, Jonathan, Clifton Hall Colliery, Clifton, Manchester.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, Prescot. *Past-President.*
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1892	*Haworth, Denis, Beech House, Blackburn Road, Accrington.
1878	Hedley, John L., H.M. Inspector of Mines, 22, Hawthorne Terrace, Newcastle-on-Tyne.
1893	Heyes, William A., Electrician, 5, Dawson Street, Bolton.
1838	*Heywood, James, F.R.S., F.G.S., 36, Kensington Palace Gardens, London, W. *Past-President.*
1889	Higson, Charles H., The Park Collieries, Wigan.
1876	Higson, John, F.G.S., 18, Booth Street. Manchester.
1881	Hilton, James, 67, Hawkshead Street, Southport.
1892	Holden, Arthur T., Solicitor, 20, Mawdsley Street, Bolton.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 12, King Street, Manchester. *Member of Council.*
1893	Horrobin, Thomas, 504, Bury New road, Breightmet, near Bolton.
1893	House, John, Rosebridge and Douglas Bank Collieries, Wigan.
1884	Howat, Andrew, 24, Fairlawn Street, Moss Side, Manchester.
1884	Hughes, Owen, Limehurst, Ashton-under-Lyne.
1874	*Hull, Professor Edward*, M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1889	Iles, John, 76, Church Street, Southshore, Blackpool.
1887	Jackson, Andrew, Manager, Collins Green and Bold Collieries, Newton-le-Willows.
1878	Jackson, Charles G., Anderton Hall, near Chorley.
1887	James, J. Stanley, Companio de Rio Tinto, Minas de Rio Tinto, Huelva, Spain.
1883	Jobling, Albert, Spring Wood House, Burnley.

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Year of Election.	
1883	Jobling, Henry, Spring Wood House, Burnley.
1884	Jobling, John, Barcroft, Cliviger, Burnley.
1890	Johnson, Alfred E., Abram Colliery, Wigan.
1879	Johnson, Isaiah, New Colliery, Westhoughton, Bolton.
1882	Johnson, William, Abram Colliery, Wigan.
1893	Kenrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1889	Knowles, James. Pearson, Knowles & Co., Wigan.
1859	Knowles, John, M.Inst.C.E., J.P., Westwood, Pendlebury. *Past-President.*
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1877	*Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury.
1886	Knowles, Robert, Ednaston Lodge, near Derby.
1893	Laithwaite, V. W., Post Office Chambers, Bradshawgate, Bolton.
1890	Law, Illingworth, Waterfoot, near Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1862	Livesey, Clegg, Bradford Colliery, Manchester. *Member of Council and Hon. Auditor.*
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., M.Inst.C.E., 6, De Grey Road, Leeds.
1891	Marshall Herbert S., The Larches, Wigan.
1893	Matthews, E. L., Mechanical Engineer, &c., Nutsford Vale House, Longsight.
1892	Mathews, D. H. F., H.M. Inspector of Mines, Newton-le-Willows.

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Year of Election.	
1881	McAlpine, G. W., Parkside, Accrington.
1890	McGeevor, James, Garswood Hall Colliery, Wigan.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, Durdham Park, Clifton, Bristol.
1883	Mather, William Penn, Iron Works, Salford.
1885	Mawson, Robert Bryham, Sovereign Colliery, Westleigh, Leigh, near Manchester.
1890	Mercier, Maunsell, King Street, Wigan.
1892	Miller, Arthur, 400, Cheetham Hill Road, Dukinfield.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham.
1892	Mills, David, Bradford Street, Farnworth.
1876	Moore, Alfred, C.E., Queen's Chambers, No. 2, Ridgfield, Manchester.
1892	Morris, Moses, Swan Lane, Hindley, Wigan.
1874	*Morton, G. H.*, F.G.S., 209, Edge Lane, Liverpool.
1868	Munro, Donald, Fairfield, near Manchester.
1878	Nall, Simon, Newbold, Rochdale.
1885	Newton, Charles Edward, C.E., F.G.S., Carlton Buildings, Cooper Street, Manchester.
1888	Oliver, Samuel A., King Street, Wigan.
1891	Orchard, Albert J. A., Atherton Colliery, Atherton, near Manchester.
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *Hon. Treasurer and Past-President.*
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles.
1877	Pickup, Peter Wright, Rishton, near Blackburn.
1884	Piggott, I., Carlton Villa, Lathom, near Ormskirk.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester. *Member of Council.*

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Year of Election.	
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Rhosneigr, Ty Croes, R.S.O., Anglesea.
1877	Platt, Samuel Sydney, Assoc.M.Inst.C.E., 14, King Street South, Rochdale.
1891	Prestwich, Joseph, Irwell Park, Eccles.
1860	Ridyard, John, F.G.S., Hilton Bank, Little Hulton, Bolton.
1893	Rigby, John, Highfield, Winsford, Cheshire.
1889	Robinson, John, Haydock Collieries, St. Helens.
1893	Ross, Arthur, Agecroft Colliery, Pendlebury, Manchester.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1890	Robson, Thomas, Wigan and Whiston Colliery Co., Prescot.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *President.*
1888	Scarborough, George Edward, Colliery Manager, New Town and Meadows Collieries, Wigan.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, Redthorpe, Tonge, Bolton.
1866	Selby, Atherton, Mining Engineer, Leigh.
1882	Settle, Joel, Madeley Coal & Iron Co., Limited, Madeley, near Newcastle, Staffordshire.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1889	Settle, William, Snow Hill, Darcy Lever, near Bolton.
1884	Shaw, David, Norbury Moor, near Stockport.
1877	Shuttleworth, Sir Ughtred J. Kay, Bart., Gawthorpe Hall, Burnley. *Past-President.*

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Year of Election.	
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1864	*Smethurst, William, F.G.S.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.
1893	Smith, Henry, 7, Sefton Street, Southport.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire. *Member of Council.*
1881	Squire, J. B., A.Inst.C.E., 297, Clapham Road, London, S.W.
1890	Stafford, Thomas, 1, Lea Road, Heaton Chapel, Stockport.
	Stechert, G. E., 30, Wellington Street, Strand, London. W.C.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Hon. Secretary.*
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, 134, Cemetery Road, Barnsley.
1881	Taylor, Alfred, Barrow Collieries, near Barnsley.
1889	Taylor, William, Rock Villa, Hoddlesden, Darwen.
1892	Thom, John, Canal Works, Patricroft.
1893	Thompson, F. W., 5, Wood Street, Bolton.
1892	Thompson, James, Westhoughton, Bolton.
1893	Thompson, Peter, 40, Hardman Street, Hollinwood, Oldham.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S, Bridgewater Foundry, Runcorn.
1884	Toman, Daniel. Messrs. Blundell, Pemberton Colliery, Wigan.
1891	Tonge, Alfred J., 380, St. Helens Road, Bolton.

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Year of Election.	
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., 380, St. Helens Road, Bolton. *Past-President and Hon. Auditor.*
1886	*Trafford, Sir Humphrey Francis de, Bart., Trafford Park, Manchester.
1892	Turner, William, Wigan Junction Colliery, Abram, near Wigan.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1888	*Walmesley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1892	Warburton, Thomas, 10, Bolton Road, Moses Gate, Bolton.
1892	Ward, Alexander Haustonne, Coppull, Chorley, Lancashire.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich.
1880	Watts, William, F.G.S., Piethorne, Rochdale. *Vice-President.*
1878	Wells, Samuel B., General Manager Bengal Coal Co., Limited, Ranigunj, India.
1877	West, T. E., Union Street, Oldham.
1890	*Whitaker, William*, B.A., F.R.S., F.G.S., 33, East Park Terrace, Southampton.
1891	Whitehead, J. J., Duxbury Park Colliery, Chorley, Lancashire.
1867	Wild, George, Albert Street, Bardsley, Ashton-under-Lyne. *Member of Council.*
1880	Williams, E. Leader, M.Inst.C.E., Manchester Ship Canal Company, King Street, Manchester.
1886	*Williamson, Professor W. C.*, LL.D., F.R.S., 43, Elms Road, Clapham Common S., London.

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Year of Election.	
1876	Winstanley, Robert, 28, Deansgate, Manchester. *Vice-President.*
1886	*Wood, Guy.
1876	Woodward, H. A., Oakwood, Clifton, near Manchester. *Member of Council.*

Members are requested to communicate to the Hon. Secretary all changes of address, also any corrections or omissions in the list.

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JAN 9 1894

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XXII. SESSION 1893-94.

THE ORDINARY MEETING of the Members was held on Tuesday, November 14th, 1893, at the Rooms of the Manchester Literary and Philosophical Society, 36, George Street.

The President: Mr. W. SAINT, H.M.I.M., in the Chair.

Mr. DICKINSON announced the death of Mr. T. W. Embleton, of Methley, near Leeds. He said Mr. Embleton was one of the oldest honorary members of the Society, and was in his 85th year. He was well known as a colliery owner in Yorkshire, and also as a mining engineer, and a member of the Board of Examination for the granting of Colliery Managers' Certificates. He was President of the Federated Institute of Mining Engineers, and was present at the last meeting of that body at the Owens College, Manchester.

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Address by the President,

Mr. William Saint, H.M.I.M.,

ON RECENT IMPROVEMENTS IN MINING MACHINERY AND APPLIANCES.

I thank you cordially for the honour you have conferred upon me in electing me your President. I undertake the responsible duties of the office with some diffidence, but I feel sure I may rely upon the hearty co-operation of all the members to aid, by every means in their power, the labours of the Society in Geological research and in the discovery and advancement of the most scientific methods for the safe and efficient working of our mines.

The Society is to be congratulated upon its successful career, the large and increasing number of its members, and its strong financial position. Many valuable and interesting papers and discussions have from time to time appeared in its publications, and it remains for us to promote its welfare and hand it on in undiminished vigour. There can be no doubt that this and kindred societies are entitled to claim some credit for the improvements that have been conspicuous in our mining practice for many years.

As the comparatively shallow mines become exhausted, others have to be won at greater depths to take their places and keep pace with the increasing demand for a supply of coal. To meet the requirements, in some instances, the shafts of existing mines have been enlarged and sunk deeper, and the mechanical arrangements, in a great measure, have been remodelled. In other cases it has been necessary to make entirely new winnings, involving a large expenditure of capital.

Next in importance to the possession of a valuable coal field, of ample extent, is the application of the most suitable

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machinery in its development. I will, therefore, endeavour to review the principal improvements that have been effected in mining machinery and appliances within recent years.

Boring.

Where a moderate depth of boring is required, and an accurate section and expedition are not essential, the application of the ordinary rods and rocking lever, worked by hand, is perhaps the cheapest method, but where great depths have to be penetrated it is usual to adopt some special method of boring, such as Mather and Platt's system, in which a flat hempen rope is employed to suspend the boring head. The rope is carried on a drum worked by a steam engine. It is passed over a pulley, running in bearings, fixed on the end of a vertical piston rod which works in a steam cylinder. The rope is clamped between the drum and the pulley, and the necessary percussive action is obtained by admitting steam to the lower side of the piston, which then raises the cutting tool and returns to its original position on the steam being exhausted. The valve motion is worked by tappets, actuated by the piston rod. The tappets can be altered, and the length of the stroke varied accordingly. The rotary motion of the tool is effected by means of an ingenious arrangement of three collars fitted thereon, and having horizontal ratchet teeth. The upper and lower collars are fixed and the centre one loose. The latter slides on the tool bar at each stroke, and its teeth alternately engage those of the other collars in such a manner as to insure the definite rotation of the boring head.

In the American system a rope is also used and many improvements have been introduced to effect rapid boring in moderately hard ground. It has been largely used in the United States of America for prospecting purposes, and latterly it has been introduced into England, and applied

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with great success in boring for rock-salt at Middlesborough; and also in the neighbourhood of Fleetwood for a similar purpose.

The most scientific method of boring, however, is that of the Diamond drill. The diamonds are imbedded on the inner and outer edges at the end of an iron crown which is grooved on the outside and fitted to the main boring piece. This in its turn is secured to the hollow rods connected by bevel gearing to the steam engine which gives them the necessary rotary motion. A stream of water is forced down the centre of the rods to the bottom of the hole and washes out the *debris* up through the grooves on the outer side of the crown piece and so on to the surface. A cylindrical core corresponding in diameter with the internal size of the crown is formed, and may be broken off and secured by a split ring fitted in the core tube and raised to the surface by withdrawing the rods. One improvement is the application, to the upper end of the rods, of a clamp and a hydraulic cylinder and hollow piston rod (through which the rods pass) to regulate the feed. It also enables the weight on the diamond crown to be adjusted and thereby prevents the breakage of diamonds which formerly occurred. Another improvement consists in the use of separate appliances for rotating, raising or lowering the rods in the bore hole, and for pumping, instead of the old combined arrangement. These tend to save time in manipulation and reduce the liability to accident to a minimum. There are also better methods for preserving the cores intact. Effective means are adopted for protecting cores of coal and soft strata from the disintegrating action of the feed water and the vibration of the bore rods, so that it is now possible to obtain cores of coal seams which would have been ground to powder and raised in the water with the older machines.

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Sinking.

The Kino-Chandron method was designed to meet the enormous difficulties encountered in sinking shafts through rocks heavily charged with water, and many pits have been successfully sunk on this principle. The shaft is bored in two operations by percussive action in the ordinary way with suitable tools and appliances. A small shaft, 4 or 5 feet diameter, is first bored, and then the full size is accomplished in a similar manner. The small shaft serves to collect the *débris* from the outward boring, and also forms a guide for the larger cutting tool. When a solid foundation is reached the water is dammed back by means of cast-iron tubbing. The bottom ring is packed with moss at the back, and is made to fit and slide within the one above it. The flanges are faced in a lathe, and as each length of tube is added the joint is made secure by means of sheet lead insertion and bolts and nuts. A diaphragm is temporarily fixed to one of the rings near the bottom, and a central tube is connected to it. The tubbing is lowered slowly by means of screws and iron rods, and as it sinks the water is forced up the central tube. The water supports most of the weight of the tubbing, and as it descends each succeeding length is added until the sliding ring reaches the foundation. The upper tubbing, continuing to descend, compresses the moss packing between the bottom ring and the side of the shaft, thus forming a water-tight joint. Any water that may have accumulated inside the tubbing is removed and the diaphragm taken out, and sinking may be resumed in the usual manner.

Triger's method of sinking through quicksands consists in the arrangements of a sheet-iron cylinder sunk in the ground and divided into three compartments, one above the other. Compressed air of sufficient pressure to keep the water back is pumped into the lower chamber. Air-tight

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doors are provided between each, and the doors of the second and third chambers are not allowed to be open at the same time. Sinking thus proceeds until the rock head is reached and the ground made secure.

Poetsch's freezing method of sinking through quicksands has been tried with some success. The principle adopted is to freeze solid the water and sand in and around the proposed shaft by introducing pipes into the ground, and maintaining a circulation of chloride of calcium at a very low temperature. When this has been accomplished the inner portion of the frozen ground is worked out without blasting. Those who have experienced the difficulties and expense of sinking through a thick bed of quicksand will readily appreciate the value of a method by which such ground is made stable until it can be secured by the proper shaft linings. This system appears to be a convenient and comparatively cheap method of dealing with a great thickness of running sand and water which is occasionally met with in colliery sinkings.

At Llanbradach, a few years ago, Mr. William Galloway introduced a movable scaffold for use in sinking pits, by means of which the walling may be carried on simultaneously with the sinking operations. The two ropes, by which the scaffold is suspended in the shaft, are used as guides for the hoppet in ascending and descending. The scaffold is usually hung some fifteen or twenty yards from the bottom, and can readily be lowered or raised by screw winches. An auxilliary winding engine is used for lowering men and materials to the walling scaffold. The movable scaffold has been used with conspicuous success, and has been instrumental in reducing the time that would otherwise have been required to win the coal seam.

We are also indebted to the same gentleman for an ingenious arrangement for filling the water at the pit bottom

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during sinking operations by means of a vacuum. Air is exhausted from a large cylinder at the surface, and a pipe is conducted from the cylinder to the bottom of the shaft, where a cock and a length of indiarubber hose, with one half of an instantaneous coupling, are fitted to it. The corresponding half of the coupling is fixed to the barrel and when the connection is made between the vacuum cylinder on the surface and the barrel the air is exhausted on opening the cock, and the water rushes up and fills the barrel. A gauge glass near the top indicates when the barrel is sufficiently full. The object is to dispense with the laborious method of baling, which is a serious item of cost in the course of sinking through water bearing strata.

Boilers.

Recent improvements in the manufacture and quality of steel have facilitated the economical production of large high-pressure steam boilers. Twenty years ago, 60 lbs. pressure was considered high, but now, in colliery work, we find many Lancashire boilers working at 80, 100, and even 150 lbs. per square inch; and elaborate machinery is used in their manufacture for flanging, planing edges, and rivetting.

The economical advantages of working steam expansively are becoming more appreciated, and there is a general tendency towards increased pressures.

Movable fire-bars, fed by hand or mechanical stoking, enable very inferior fuel to be burnt, and are also very effective in preventing the emission of dense smoke. The slack is fed at the front of the fire only, and the action of the bars is to carry the fire forward. The supply of slack is so regulated that all the fuel is consumed by the time it reaches the end of the bars where the ashes and clinkers fall.

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Pumping.

The Cornish pumping engine was the first direct acting expansive working engine and its economical performance is well known. But it did not adapt itself to variable loads caused by loss of water in the pumps, occasional breakage being the result. To meet this defect many of them have been fitted with Davey's differential gear for controlling the valves with satisfactory results. Its first cost, however, is great. As alternatives Hathorn Davey and Co's horizontal compound condensing engines, connected to quadrants which give the necessary vertical motion to the pump rods in the shaft, are largely adopted. This engine, like the Cornish, depends for its expansive working on the mass of its moving parts. The chief improvements consist of the addition of pausing gear, which ensures an interval at the end of each stroke, thereby allowing time for the valves of the lift to settle down before the commencement of the succeeding stroke; of trip gear by means of which the exhaust from the H. P. cylinder is automatically stopped in case of a sudden rush or accident, thus forming a cushion which gradually stops the engine without shock. The arms of the quadrants are less than 90°. The main valves (exhaust and steam admission) are controlled by automatic gear, and each cylinder is fitted with an expansion valve variable by hand, so that the desired ratio of expansion can be obtained without "wire-drawing" the exhaust. By these means 8 to 12 expansions can be obtained, according to the initial pressure of steam. In connection with these engines hydraulic pumps are sometimes fixed in duplicate at the pit bottom or in dip workings for working the lower lift. One is usually capable of doing the work, the other being kept as a reserve. These receive the motive power from the rising main of the upper lift, suitable arrangements being made for starting them when under water should they become submerged.

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In other instances, direct-acting, differential engines are placed near the bottom of the shaft; the water being pumped to the surface in one lift, and the steam supplied by boilers fixed either on the surface or under-ground.

Pumps of the Worthington type are also largely used. They have two sets of cylinders and rams; the slide valve of one cylinder being actuated by a lever moved by the piston rod of the other cylinder. When at work, one ram or the other is always in motion, and, as the delivery of the water is continuous, there is an entire absence of vibration and shock.

Messrs. Bailey and Co., of Salford, manufacture a vertical pump, specially adapted for sinking purposes. It was first used at the Denaby Main Colliery, from which it takes its name. It is very simple in construction, occupies little space, has large valve area, is not liable to get out of order, and is very convenient for suspending in the shaft. It is said to use less steam than many other direct-acting pumps designed for a similar purpose.

A novel method of utilizing water as a means of transmitting power for pumping purposes below ground is that patented by Mr. Joseph Moore, in which the power rams are actuated by two columns of water in connection with ordinary rams, worked by a steam engine fixed on the surface. The reciprocating motion of the engine being imparted to the under ground pumps.

Winding Engines and Winding.

Considerable progress has been made in the construction of winding engines, and some fine examples are working in this district. They are usually of the horizontal type, have two cylinders, with the drum on the crank shaft between them. Several of the larger engines are fitted with automatic expansion gear, which comes into action when the

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maximum speed is attained. Twin compound winding engines, with steam reversing gear, parallel drums, balance ropes, and separate condensers, have been recently introduced into Wales and Lancashire. In the former they have been working more than a year, and are pronounced an unqualified success; but the one in Lancashire has not yet been practically tested. These engines are fitted with automatic expansion gear to the high-pressure cylinder. The cylinders are connected by a large steam pipe, which answers the purpose of a receiver, to which is attached a relief valve to prevent excessive pressure reaching the low-pressure cylinder, and an auxiliary valve to admit live steam to the low-pressure cylinder, or relieve the back pressure on the high-pressure cylinder at the discretion of the engine driver.

Steam brakes are now considered a necessity for use in cases of emergency, a foot brake being used in ordinary working. In some instances the winding engines exhaust into a separate condenser, but this arrangement is not so generally adopted as it might be.

In connection with a few of our winding engines, there are devices for preventing overwinding which come into action, and automatically shut off the steam and apply the steam brake on the cage reaching a certain position above the surface landing, and the cage is simultaneously secured against falling down the shaft. Detaching hooks between the ropes and the cages are extensively employed. Safety cages are quite common in Lancashire collieries, where the shafts are fitted with wooden conductors.

Improved winding ropes, guide ropes, and methods of capping have been introduced.

Balance ropes beneath the cages are employed in many pits. They insure greater uniformity of the speed in the shaft. The cages run more steadily, and the engineman is

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better enabled to control the load. Although there is little apparent saving in time of winding by their use, their advantages in other respects should ensure their more general adoption.

Fan Engines and Fans.

Fan Engines being constant running are in many instances carefully designed with a view to economy in the consumption of steam. Twin compound engines with automatic expansion gear and separate condenser being, perhaps, the most approved form. The best designed engines are substantial in construction, and the stuffing boxes are fitted with "floating" metallic packing. The bearing surfaces are large to minimise the chances of heating, and each bearing receives a copious supply of oil from a sight-feed lubricator. The waste oil is collected, filtered, and used repeatedly. Mr. Henry Hall's automatic recording water gauge and speed indicator is a useful addition.

Fans for ventilating mines have been extensively introduced in recent years, and they are rapidly displacing furnaces, the disadvantages of which are many. It is no longer a question as to the relative merits of furnaces and fans, but rather a rivalry of fans. Higher water gauges and greater volumes of air than furnaces can produce economically are required to meet the exigences of the times. But it must be a rare case indeed where a modern fan cannot be made to do equal work with considerably less consumption of fuel than a furnace. The most approved fans for obtaining high water gauges are of the close running type, very substantially made, and are driven by belt or rope gearing. They are built almost entirely of steel, are comparatively small in diameter, and are able to stand running at high periphery speeds for long periods without danger of breakdown.

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Some makers attach great importance to the curvature, number, or arrangement of their vanes, but it seems probable that the efficiency of a fan depends, in a large measure, upon its capacity being adapted to the mine it is intended to ventilate. It is obvious that a wide fan upon a mine which can only pass a small volume of air, and a narrow fan on a mine which can pass a large volume would show low efficiences, because of the loss of power due to the resistance of the vanes in the one, and to the friction of the air in passing through the other. Yet such cases exist at the present time.

Transmission of Power.

Next to self-acting inclined planes, perhaps the most economical system of underground haulage for dealing with large outputs over roads uniformly level, or of moderate uniform gradients with or against the load, is a slow speed endless rope (or in the case of a wet mine a chain) carried upon the tops of the tubs placed at moderate distances apart. The ropes being kept off the floor, wear and tear are reduced to a minimum and they are found to last many years. The steam engines are best fixed on the surface and the driving rope carried down the shaft to the driven pulley. Moderate outputs, say of 250 tons a day, are also economically hauled by this system up brows inclining 30° to 40° from the horizontal, but in such cases it is found desirable to run the rope beneath the tubs and to use clips specially devised to adjust themselves to the rope under the varying conditions of the load.

Where large outputs have to be hauled up steep gradients it is the practice to use single ropes. When the brow is in direct line with the pit the engines are sometimes erected on the surface, but in others are fixed near the pit bottom and worked by steam generated on the surface or below-ground. But underground fires have resulted in a few instances from radiation of heat from the steam pipes, and

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if, for particular reasons, the engines must be placed underground, the best practice is to use compressed air as the motive power, and particularly is this desirable in fiery mines, or where power is required long distances away from the shaft bottom. This is a matter of considerable importance because it is often found more economical to employ small engines to wind from the dip in the interior of the mine than to use horses or manual labour for that purpose.

Electricity has been successfully applied for the transmission of power underground, both for haulage and pumping purposes in many mines. The current is generated on the surface, and conducted by an insulated copper cable to a motor, which may be geared by belt, rope, or spur gearing to the machinery. The return current may be conducted by old ropes laid on the ground. Since its first introduction as a motive power in mines, improvements have been introduced with a view to prevent the possibility of ignition of explosive mixtures of fire-damp and air, either by sparks from the commutator, or an accidental severance of the cables; but, even with these precautions, it is for engineers to consider whether the cables and motors can be safely placed in positions where a naked light cannot be used. Its introduction has passed the experimental stage, and there is every probability that its application will be largely extended. It is therefore desirable that all connected with the management of mines should acquire some knowledge of this truly wonderful medium for transmitting power.

Electrical signals are very extensively used in the shafts and on haulage roads. The wires are sometimes utilized for the transmission of telephonic messages between the surface and the several stations on the haulage roads.

Coal Cutting Machinery.

Coal cutting machinery has not been adopted on a large

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scale in this country, probably owing to the fact that, as a rule, they are only applicable to long-wall workings, in which the coals are not usually difficult to get by manual labour. This, however, does not apply to the Stanley heading machine, which is designed for driving narrow roads. It consists of a series of radiating arms, supported on a shaft, carrying longitudinal cutting-bars, which are revolved against the face of the heading by means of a pair of small vertical engines and powerful gearing driven by compressed air. The bars make an annular cutting, leaving a central core of coal, which is broken up by wedging and removed by hand. The length of the cut is about twenty inches, and under favourable conditions the speed of driving is from three to four feet an hour. The machine has been thoroughly tested during the past few years and it is a practical success. Its chief merits being the increased proportion of large coal obtained from narrow roads, and the saving of time in executing a given quantity of work.

Lighting.

Almost all the principal collieries are now provided with installations of the electric light for illuminating the surface works and the main roads, &c., in the vicinity of the bottom of the winding shafts. It compares favourably with coal gas as regards illumination, cost, and immunity from risks by fire. Its use is very desirable in the neighbourhood of coal screens and picking belts, where large quantities of fine, dry dust are always present in the atmosphere. Where gas is used in such situations it is desirable, for purposes of safety, to burn it in lamps fed with pure air.

Attempts were made four or five years ago to introduce, as a substitute for oil safety lamps, portable secondary batteries with electric incandescent lamps, giving a light of 1½ or 2 candle power for 8 to 12 hours; but their success

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was marred through leakage of the solution of sulphuric acid which they contained, causing corrosion and short circuiting, and by the difficulties in charging them with electricity from the dynamo. They have not come into general use, and we are therefore still dependent upon the principle discovered by Sir Humphrey Davy as the basis of security in our safety lamps. The improvements consist mainly in the provision of a glass, duplication of gauzes, and in surrounding the gauzes with a metal shield to protect them from the force of the air currents. By an ingenious arrangement for admitting the air into the body of the lamp the light has been improved. The lead rivet lock is now commonly used, and it possesses the merit of great simplicity with the certainty of detection in the case of tampering. Some of the modern lamps have attained a high degree of perfection as regards safety; but a lamp absolutely safe under all conditions has yet to be invented.

Owing to the difficulty of detecting the presence in the air of less than 2½, or perhaps 2, per cent. of gas with the ordinary safety lamp, and lesser proportions having been proved to be an element of danger in the presence of coal dust during blasting operations, attempts have been made with success to invent more delicate indicators for the use of officials and shot lighters.

The Liveing Indicator essentially consists of two coils of platinum wire connected to a small electric battery. One coil is enclosed in a glass shield and protected from contact with the atmosphere to be tested, and the other in a shield of glass and wire gauze which admits the air. A movable photometric screen and fixed scale are placed between the two spirals. When the electric current is applied and the indicator is in pure air both spirals glow equally; but in presence of firedamp in air the exposed one glows more brightly and the screen is moved until its sides are equally

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illuminated, and its position on the scale indicates the percentage of gas.

We have also the Pieler safety lamp burning pure alcohol and Ashworth's lamp burning benzoline. Both these lamps are designed for the purpose of detecting small proportions of firedamp in air: the former being the most sensitive.

A short time ago Dr. Clowes introduced to public notice his inflammable gas detector. It consists in the addition of a hydrogen flame within the ordinary safety lamp. A small cylindrical vessel containing hydrogen is attached to suitable external fittings of the lamp, and connection is made with a tube which terminates near the ordinary burner. By turning a tap the hydrogen is allowed to enter the lamp and it is ignited by the oil flame which is then extinguished by pulling down the wick. The hydrogen flame is regulated to a standard and the lamp is ready for testing purposes. The oil flame can be relit by the hydrogen flame and the latter extinguished, when the lamp may be used in the ordinary way. It is claimed that one-fourth of one per cent. of firedamp in air can thus be detected with certainty.

More recently Mr. A. H. Stokes, one of H. M. Inspectors of Mines, has designed a similar arrangement to that of Dr. Clowes's hydrogen-oil lamp. Instead of hydrogen he uses pure alcohol, fed by a small wick which, in conjunction with a peculiar wick tube, regulates the size of the flame. It is thus a combination of the ordinary safety lamp and the Pieler lamp in a very handy form.

These delicate indicators should only be used where the ordinary oil flame fails to reveal the presence of firedamp, as they are very sensitive and require much care in manipulation.

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Coal Dust and its Treatment.

The presence of dry coal dust constitutes an element of danger in mines where blasting is carried on without special precautions. Its sensitiveness to ignition can be demonstrated in the most graphic manner on the surface by simply exploding a charge of gunpowder in its midst. It is therefore desirable to prevent, so far as possible, accumulations of dry dust, or that some means for rendering it innocuous should be adopted. To this end various methods of watering have been tried with varying success. The fine water spray, which originated with Mr. J. J. Thomas, manager of the Ynishir Colliery, and known as the South Wales system, is largely used. It has been successfully introduced into most of the steam coal collieries in South Wales. Filtered water under great pressure—in some cases exceeding 600 lbs. per square inch—is carried in pipes along the main haulage roads. At intervals stand pipes are fitted terminating in spray nozzles. The spray is discharged in the opposite direction to the ventilating current; this tends to break it up, and it is then carried in the air and distributed on the roof, floor, and sides, over a distance varying from 15 to 40 yards, according to the velocity of the air current. The method introduced by Mr. H. W. Martin, at the Dowlais Colleries, produces a more perfect spray. A jet of compressed air being introduced into the spray nozzle with excellent effect.

This system effectually lays the dust, cools the atmosphere of the mine, and makes travelling more agreeable. It also tends to save haulage power, and wear and tear of the tub axles. Similar arrangements have been introduced at a few of the collieries in Lancashire, but only with partial success, which I am disposed to attribute to the use of unfiltered water, insufficient pressure, and to the slower velocity of the ventilating currents as compared with those in the South Wales mines.

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Much can be done to prevent accumulations of dust on the haulage roads by using good rolling stock, kept in a thorough state of repair, and by removing it from the roads at frequent intervals. Where wooden tubs are used, the boards should be tongued and grooved—a method satisfactorily adopted a few years ago by Mr. J. S. Burrows at the Atherton collieries. It is also an improvement to have the roads laid with long fish plated rails, resting upon iron or steel sleepers, in order to prevent the tubs leaving the rails and spilling their contents.

Blasting.

In sinking pits the old method of drilling by hand still continues, but in the coal mines the shot holes are now generally drilled by machine drills worked by hand. They lessen the labour, and enable the boring to be done expeditiously.

The introduction of Mr. Miles Settle's device for surrounding the explosive with water, and of various compounds, such as roburite, which in themselves contain flame extinguishing elements, together with electric firing, has enormously decreased the risks of mine explosions through blasting. The use of electric fuses has been extending for several years, and undoubtedly affords the best and safest means of igniting explosives. Ordinary powder fuse sometimes hangs fire for hours, and consequently there is danger in approaching a "missed shot;" but with electric fuzes, as now manufactured, it is claimed that they cannot possibly hang fire. Good portable electric batteries are now supplied at moderate prices. They are of two kinds, namely, high and low tension, and fuzes are made to suit each system.

Conclusion.

I have no doubt that in this address many points of interest to the mining and mechanical engineer are

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unnoticed, but I think I have said enough to show that great progress has been made in the application of improved machinery and appliances to mining purposes generally, and I hope that some of our members will bring before us for discussion Papers on some of the subjects which I have briefly outlined.

Mr. WINSTANLEY said: I beg to move that the best thanks of the meeting be given to the President for his very practical address, to which we have all listened with very great pleasure.

Mr. H. BRAMALL said: I have much pleasure in seconding the motion. We naturally expected, from his position, that Mr. Saint would give an address which it would be a pleasure to listen to; and I am sure the large attendance to-day speaks for itself. The name of Mr. Saint is sufficient to induce practical men to come and hear anything he may have to say to them. The field is so wide, however, that he could notice but slightly some of the great improvements which have recently been made in mining appliances; at the same time we are deeply indebted to him for reminding us of what has been done, and what is still being attempted, in the way of improvement, in the industry with which we have the honour to be connected.

The motion was put to the meeting by the HON. SECRETARY, and carried unanimously.

The PRESIDENT responded, and said that each of the topics touched upon in his address would furnish material for a separate paper. All he could do was merely to take a general survey of them. He had, however, said sufficient to show that there was a great deal to observe in connection with collieries, and he would like some of the members who had had the improvements in question under consideration to bring them before the Society for discussion. He was sure it would tend to their mutual benefit.

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REPORT OF THE DELEGATE TO THE BRITISH ASSOCIATION MEETING AT NOTTINGHAM, SEPTEMBER, 1893.

By Mr. Mark Stirrup, F.G.S.

As your Representative at the recent Meeting of the British Association at Nottingham, it is my duty and privilege to submit, as heretofore, a Report of the Conference of Delegates of the Corresponding Societies.

The number of Corresponding Societies on the list of the Association has increased of late years, and is now about 60. Of these about 30 were represented at Nottingham.

Two Meetings as usual were called, which the Delegates are expected to attend, when any recommendations or suggestions from the Sectional Committees of the Association are submitted and considered, as well as any emanating from the Corresponding Societies' Committee.

At the first Meeting Dr. J. G. Garson occupied the chair, and the Committee's Report of the proceedings of the Conference last year at Edinburgh was distributed.

The Chairman, after welcoming the Delegates, referred to the increase in the number of Societies all over the country, and remarked that in 1885, at Aberdeen, where the first Conference was held, 24 Delegates were present, and last year at Edinburgh 42. The Chairman, after enlarging upon the value to Societies of being affiliated to the British Association, invited remarks on any of the subjects dealt with by the respective sections of the Association.

Various subjects were discussed by the Delegates, some having reference to Natural History, the teaching of Geography in schools, Coast Erosion, Geological Photo-

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graphs, Earth Tremors, &c. The successful result of the recent Ethnological Survey of Great Britain was commented upon, an investigation which had been materially helped by several of the Societies.

Mr. Topley spoke of the value of observations on the amount of denudation now going on in exposed areas, and he referred, as an example, to the data collected by our member, Mr. Watts (*Trans. Man. Geol. Soc., Part 17, Vol. 21, p. 507*), on the amount of solid material brought down by flood waters from the high-lying drainage areas connected with the reservoirs of the Corporation of Oldham. Facts of this character, he said, were mnch appreciated by geologists.

At the second meeting no special subject was brought forward for discussion, but a desultory conversation took place on several matters, such as the necessity for the protection of our native wild birds by preventing the robbing of their nests and the excessive and indiscriminate purchase of their eggs by collectors, and so-called naturalists.

Various means were suggested of mitigating the evil, as by timely advice to school children by teachers, by placing notices in schools, and it was thought to be a matter not unworthy the attention of School Board Officers and County Councils.

The attention of the delegates was also drawn to the lack of information as to type specimens of British fossils preserved, and often, alas, buried, in local museums, and the necessity of some means being adopted to make their whereabouts known.

Such is a summary of the principal subjects that engaged the attention of the conference, the promotion of which, in their respective spheres of operation, is the duty of the corresponding societies. Of these various researches and enquiries now being carried out by special committees of

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the British Association, perhaps the most compatible with the avocations and proclivities of the members of the society are those of the Erratic Blocks Committee, the Circulation of Underground Waters, the Collection of Photographs of Geological Interest, and the Observations on Earth Tremors, such as those now being made in Durham in connection with coal mine explosions.

The help of any of the members in the furtherance of these investigations will be gladly received and acknowledged.

Turning now from the work of the Corresponding Societies to that of the Sections, it will be, in accordance with previous practice, to draw the attention of the members to such of the papers brought before the meeting as may be thought of some interest to the members from their subject matter or importance in other respects.

Among the papers brought before the Geological Section was one by Professor E. Hull on the water-bearing capacity of the New Red Sandstone of Nottingham, the rock formation on which the town is built, similar rocks to which are largely developed in the neighbourhood of Manchester and Liverpool. The New Red Sandstone, in consequence of its porous nature, is capable of absorbing and retaining two-thirds of the rainfall. Few towns in central England, said Professor Hull, are more favourably situated for purposes of water supply than Nottingham.

From three or four wells, situated within a few miles of the city, a yield is obtained of several million gallons per day of pure and excellent water.

Though these underground sources of water-supply are discarded for drinking purposes in Manchester, yet we know how largely they are drawn upon for industrial undertakings, and they might in time of drought and emergency.

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such as we have lately experienced, be made available at comparatively small cost.

A paper by A. T. Metcalfe described the gypsum deposits of Nottinghamshire and Derbyshire and the process of making the mineral into plaster of Paris, &c. In Nottinghamshire, gypsum is abundant and rock-salt absent, although both, as a rule, are precipitations from sea water due to varying conditions of evaporation. The Cheshire salt deposits occurring in rocks of like age to the Nottingham gypsum.

Another paper may be mentioned bearing on a point of interest in the geology of Cheshire, introduced by Professor Clowes. It was a description of the Himlac Stone, a well-known isolated pinnacle of rock, some few miles from Nottingham, which the Professor thought was formed artifically by quarrying operations. It is described in the Geological Memoir, relating to this district, by Professor Hull as an old sea stack, the result of marine denudation. This origin, however, is disputed, and it is thought more likely to be the result of atmospheric agencies acting along lines of fault or fissure. The main interest, however, of this rock arises from its containing 28 to 50 per cent. of Barium Sulphate or Heavy Spar, which gives to hand specimens of this sandstone its peculiar heavy character.

This Barium Sulphate is present in a crystalline condition and acts as a cementing material to the grains of sandstone.

Professor Clowes stated that this mineral did not occur in any other sandstone of Triassic age, but in this he was corrected as the mineral is known to occur in the Lower Keuper Sandstone at Beeston Castle, and in a minor degree at Helsby, as stated in the Geological Memoir of the country round Chester, and I think it has been detected in the rocks of Alderley Edge. Some diversity of opinion

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exists as to the exact geological age of this Himlac Stone, the upper part or capping being assigned by Professor Hull to the Bunter Pebble Beds, and the lower part to the Lower Mottled Sandstone. A local authority, Mr. Shipman, is of the opinion, however, that the upper part belongs to the Keuper and the shaft to the Bunter.

Glacial geology, for which a day was set apart, also came in for a fair share of discussion, some of the current assumptions and notions of glacialists being severely criticised by Professor Bonney and Sir H. H. Howorth.

Passing over numerous papers of local and general geology which call for no special remarks, I would refer for a few moments to an interesting discussion that took place in the Chemical Section on Explosions in Mines, with special reference to the Dust Theory, a subject which has engaged the attention of the members on several occasions. Professor Dixon, who introduced the discussion, referred to the doings of the Royal Commission appointed by the late Government to investigate the facts concerning coal dust, and also drew attention to some experiments that had been carried out by Professor Clowes in co-operation with the Chesterfield Institute of Mining Engineers.

Professor Dixon said the theories were, that coal dust and air alone were, and were not, explosive, and that a small mixture of fire-damp with dust and air was highly explosive.

The experience at Seaham Colliery was that they had explosions where the dust was dry and not where it was wet.

The conclusion of the Chesterfield Committee was that fine coal dust could be inflamed under certain conditions, but that there was little or no concussion, and that the flame was localised. A dust flame alone would not be of an explosive character, but might be capable of extending the effects of an explosion of gas.

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The evidence taken by the Royal Commission had been published in a Report, and Mr. Henry Hall, Inspector of Mines, had been requested to carry out some experiments to elucidate the question whether coal dust alone was inflammable.

In some of these experiments which were carried out in disused coal-shafts, explosions took place, and in others none.

The reason of this, Professor Dixon was inclined to believe, was owing to differences in the coal dust.

Mr. Galloway, who was called upon to speak, strongly affirmed the explosive character of coal dust, and advised watering in all dry mines.

Mr. Hall, while acknowledging the incompleteness of the experiments carried on under his supervision, was satisfied that coal dust was capable of explosion.

Mr. E. H. Stokes, H.M. Inspector of Mines, on the other hand, did not believe that pure dust was inflammable, and attributed all explosions to the presence of gas.

Professor Clowes followed with a paper and experiments on the "adaptation of the hydrogen flame to the miner's safety lamp," by which very small quantities, less than half per cent., of inflammable gas can be detected in the air of the mine.

Such are a few of the leading subjects brought before the meeting, having reference to our own line of work, which I thought might be interesting briefly to note, those members wishing for further details, must have recourse to the daily newspaper reports, or the pages of the annual volume of the British Association when published.

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Somewhat of a new departure in the programme of the work of the Sections may be mentioned, viz., that of set discussions on some pre-arranged subjects of a general or popular character, thus relieving, in a measure, the dry and technical nature of many of the papers read before the sections.

Dr. Darwin's theory of the formation of coral reefs and atolls thus came in for discussion between members of the Biological and Geological Sections, Professor Sollas speaking in support, while it was criticised and refuted by Dr. Hickson and others.

The Limits of Geology and Physical Geography formed the subject of another discussion, Commander Markham speaking from the point of view of a geographer, while Mr. Topley, F.R.S., represented the geologists.

The result of the discussion seemed to support the opinion that the two sciences were mutually dependent and closely allied; geology being described by one speaker as a series of studies of physical geography.

Another discussion was appointed to take place on Geological Education, in which Professors Cole and Lebour spoke as to the methods of teaching geology, and the advisability of its inclusion in the school curriculum for boys and girls.

These discussions formed interesting and novel features in the Nottingham meeting of the British Association, and drew large and attentive audiences.

The thanks of the meeting were given to Mr. Stirrup for his interesting Report.

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Notes having reference to Mr. J. DICKINSON's recent Paper on

OUTBURSTS OF SOFT COAL AND GAS.

By Mr. W. S. GRESLEY, F.G.S.

(*Communicated by the Hon. Secretary.*)

Mr. MARK STIRRUP read the following letter, dated 15th June, 1893, and also two enclosed extracts of published Papers sent by Mr. Gresley :—

"I should like to bring to the notice of the next meeting, when the further discussion of Mr. Dickinson's Paper on 'Outbursts of Soft Coal and Gas in the Royley Mine' takes place, the subjoined accounts of phenomena and remarks anent the subject, because they appear to me to bear a good deal upon the origin or cause of these outbursts, besides showing that the matter had already received attention.

"To these two references (extracts from published writings on the subject) perhaps I may be allowed to add one or two other cases of bursting coal from solid seams which have attracted my attention in Pennsylvania since I became connected (as Consulting Engineer) with some of the mines in that State, namely—(*a*) at an anthracite mine known as the Otto Colliery, in Schuylkill County, in 1889, when several lives were lost and a large quantity of coal was suddenly forced out of the face of a 'chute' or 'breast' into the adjacent 'gangway.' (*b*) In the 'Pittsburg' seam of the bituminous region are peculiar faults called 'soot-veins' and 'slack-veins' which I regard as *overlaps* or *thrust-faults*, because the seam and its associated bands of fire-clay and shale are jammed or wedged laterally into a series of zig-zag over-lappings and under-lappings, sometimes accompanied by violent contortions locally. Now, in driving narrow working places (rooms 12ft. to 18ft. wide) into or up against these troublesome things the coal often has a tendency to burst off without warning, and the roof will continue to break down or 'gutter up,' as the saying is, until large and ugly cavities are made. Mine managers inform me that one way of reducing the effects of these outbursts of solid coal at 'slack-veins' is to take as wide a face as possible where they occur.

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"The more I see and hear of these outbursts the more probable does the earth pressure or squeeze theory seem to fit in with observed facts. It seems to me there must certainly be considerable latent or static pressure where such enormous lateral thrusting has existed when these faults (slack-veins) were formed; and that the making of openings into them gives immediate relief to these pressures or strains in the shape of sudden outbursts of coal, &c., accompanied by violent and loud reports, with creaking and cracking noises in the interval, seems perfectly in accord with natural phenomena. I am not going to say that chemical action on pyrites, producing heat; or something in the air of the mine acting upon the explosive coal may not play some small part in bringing about the effects described, but to attribute them mainly to such would seem to ignore the much more rational idea of the outbursts being due to pent up strains or forces in the strata (coal, &c.,) getting vent or being released on removal of their 'retaining walls,' so to speak.

"I am inclined to look upon the insidious 'creep' of floors of a mine as an 'outburst,' only it is one having a *very slow movement*, comparatively speaking, and makes no noise."

[*Extract from the* GEOL. MAG. Dec. III. Vol. IV. No. 11, p. 572.]

"*Re* EXPLOSIVE SLICKENSIDES."

"In driving, exploring, or 'opening-out' headings in certain seams of coal, loud reports are very frequently heard, which are often accompanied by the bursting-off from the sides of the excavations of large blocks or masses of coal. The noise made by such 'explosions' or reports may be likened to artillery, and often causes men to run out of the place with alarm. Now, these 'bumps,' as the miners term them, generally occur in situations where the strata are much faulted by dislocations, and increase in importance with depth or thickness of cover. They probably happen most frequently and loudest in single drifts or headings, or those formed in advance of the general workings of the mine; and it is where these excavations are formed in the lower part of the coal-seam that the 'bumps' are heaviest and produce greatest effects. Such an instance occurred a few years ago in one of the pits of the Moira Collieries close here, when a sudden and very severe bump completely displaced and shattered a single-brick 'brattice'-wall (or partition, dividing the excavation longitudinally for ventilating purposes) for a length of

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about 24 feet. This wall was, as it were, completely *blown* out, and the men in the place were 'jumped-up' off the floor, but not hurt. The wall was about three feet high and built with mortar. Again, in excavating the main roadways in the solid coal in the thicker seams of South Staffordshire, very severe bumps take place, and have been known to suddenly displace hundreds of tons of coal by throwing them off the sides into the road. But in the ordinary course of coal-getting, especially by the method called the 'Long-wall' (*i.e.*, where all the seam is extracted by one operation), loud reports with bumps are of every-day occurrence, and now and again they have the effect of knocking out the props and sprags (wooden supports to roof and sides) and bring down a quantity of stuff. Also, during the operation of "holing" (under-cutting the coal-seam preparatory to breaking it down), the coal will keep on bursting itself off in little fragments from the face of the excavation with loud explosive reports, often putting the men's candles out. When the coal does this, it is said to have plenty of 'life' in it, or it 'keeps talking to you.

"Now, it appears to me, that there is one common cause for all these 'explosions,' 'bumps,' 'nackings,' etc., which is simply this: the upsetting (by the excavation) of the equilibrum of the strains or pressures holding everything fast and firmly together—the removal of the support thereby causing the rock to get relief and to fly off or apparently to explode. I look upon the phenomena as *miniature earthquakes* in fact. I question very much whether gas has anything to do with these bumps, etc., even in coal-mines, but that they act upon the gas is exceedingly probable. The phenomena are certainly often very striking, and would seem to be worthy of much more attention than they have received. With Mr. Strahan's last paragraph I quite agree.

"W. S. GRESLEY, F.G.S.

"Overseal, 8th September, 1887."

"FIRE-DAMP.

"*Extract from 'The Colliery Engineer,' of Scranton Pa., U.S.A., June, 1893.*

"By H. Le Chatelier, E.M., Professor in the National School of Mines—Associate Professor of Chemistry in the Polytechnic School.

"There is a third class of *instantaneous discharges* to which this ame is more particularly applicable and which differ from the out-

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bursts in that they come from the coal bed proper, and never from the enclosing rocks. *They are accompanied by the projection of small coal which partially fills up the spaces about the face of the workings, often burying the workmen who have not had time to save themselves.* Up to the present time these discharges have been chiefly observed in Belgium.

"They are rare in France, where they have been proven however, by an instance in one of the beds of the mines of Besseges, but they are still more rare in England. Instantaneous evolutions of this nature are always produced at points where the coal is very soft and presents that peculiar structure known according to the locality by the terms ('fusain, houille daloide, danty coal'). They result from the disintegration due to the explosion in the coal of fire-damp which has accumulated there under internal pressure. In general the variations of pressure from the free surface inward in masses of coal is so slow that the block of coal, though pressed outward by the interior pressure is of sufficient size to be held in place by its adhesion against the top and the bottom. But if for any accidental reason whatever the zone of greatest pressure approaches the free surface, the equilibrium will be destroyed and the mass of coal will break off. From this moment the edges of the mass of coal in contact with the atmosphere will contain gas at high pressure which will be able to cause an explosion of the coal wherever it is sufficiently soft. The circumstances which might cause the change in position of the zone of greatest pressure, are, crushing of the bed by a pressure from above, cracking to a great depth due to the use of explosives, the opening of a blower full of compressed gas, or the perforation of a bore hole where too rapid exploitation is going on in the face of the drift. The following are examples of instantaneous discharges. In Belgium, the two mines of La Grappe and Marcinelle are particularly distinguished for the occurrence of the phenomenon. The former was on April 17th, 1879, the scene of a memorable accident due to an outburst of this nature of an exceptional intensity. The volume of gas given off has been estimated at more than 3,531,000 cubic feet and the amount of coal thrown down as 413 tons. The gas ignited at the mine opening and burned for several hours, giving a flame 164 feet in height. A great number of similar, but less intense outbursts, have taken place in the same mine.

"On July 29, 1864, there was an outburst accompanied by the projection of 148 tons of fine coal which covered up two workmen,

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while three others who were found in the same chamber were asphyxiated by the fire-damp. In the first six months of the year 1880, there were in the same mine eight very characteristic instantaneous outbursts, the most important of which threw down 20 tons of coal.

"The relative importance of these three methods of instantaneous discharges is very unequal. Blowers or fissures are much the most frequent, there are no mines where they are not encountered from time to time, either large or small, and may almost be said to constitute a part of the normal flow of fire-damp. The properly called instantaneous evolutions accompanied by a pulverization of coal are much more rare. They are produced only at particular points of coal beds which are well determined and always the same, and are to be feared only during the work of exploitation. Finally sudden outbursts which are still more rare are produced like the preceding, only in certain particular beds which lie in the vicinity of very gaseous and of very permeable levels, but unlike the latter, they occur only in the work of robbing pillars or of stripping top or bottom rock. The latter two modes of evolution are fortunately very much more rare than we would be led to believe by certain statistics, which attribute to instantaneous discharges all of the accidents from fire-damp whose immediate cause has not been established."

The PRESIDENT: The extracts sent by Mr. Gresley do not seem to refer to anything analagous to the outbursts at Broadoak.

Mr. DICKINSON: I should like to say, with reference to Mr. Gresley's paper, that he does not seem to deny that chemical action has some connection with the outbursts of soft coal in the opening out of new mines, but he ignores altogether the effect of gas under pressure as having any connection with them. He seems to attribute them almost entirely to the earth-strain, or pressure, as he terms it, which is given vent to by the excavation made in opening out the mine. At the same time in the last quotation which he gives of M. H. Le Chatelier's views, as translated, that gentleman attributes the outbursts to pressure of gas and earth pressure, and he also says that vent is sometimes

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given to this pressure by means of fissures caused by blasting, and sometimes by bore holes. M. Le Chatelier, I may say, is a great mining authority in France, and the paper from which Mr. Gresley quotes is given at length in *The Colliery Engineer*, a paper published at Scranton, Pensylvania, and one of the most able mining publications that has come under my notice. I recollect, in the discussion upon my paper, the question of boring was carefully gone into. Now, M. Le Chatelier thinks bore holes have, on some occasions, been the means of giving vent to the pressure of gas and earth pressure, and thus causing outbursts. It appears, therefore, from this dissimilarity of views, that some outbursts differ from those in the Royley seam which I described. There is, I think, evidently a difference. Those which Mr. Gresley describes, accompanied by "bumps" and breaking down of coal, may be due partly to pressure and strain, without gas, but helped on considerably by change of temperature acting on the strata by means of the ventilation. That is a subject which has not been considered so fully as it appears to deserve. Then there are outbursts which, alluded to by Mr. Gresley, where the coal, in tearing off, is accompanied by reports like those of a gun, with short rattling sounds between. These rattling sounds are not at all unlike what you hear in tearing a piece of glazed calico. It is a tearing, rattling noise, and in opening out some mines there are not only sounds as of a gun going off, but this tearing sound between each report. These sounds, I believe, are caused, to a considerable extent, by gas, and I think also, in some measure, by the difference of temperature of the air coming in contact with the hot strata and so causing disruption of the material by which the strata are bound and crystallised together. The sounds described by M. Chatelier are almost identical with those described in my paper—all accompanied by gas. Any of you may have

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noticed that a splintering takes place when you put certain kinds of coal on the fire, particularly the splint coal, or a piece of cannel—a little splinter will sometimes fly to pieces and crackle. In Scotland, one of the names for the cannel coal is "crackling coal;" and at Cliviger, in this county, a bed of cannel is called "cracklers." Practical miners, also, will be able to understand how the strata will tear away when a change of temperature is brought to bear upon it. Often, when the ventilation has been continued in a certain direction for a length of time—for years perhaps—if from any cause the intake has been changed to a return, it is remarkable how the strata will break down simply from change of temperature. There are many things which have to be considered, and I think Mr. Gresley has confined himself rather too much to only one view of a very wide subject.

The President: Mr. Gresley does not attempt to suggest any means of diminishing or preventing the outbursts.

Mr. Dickinson: No, I think he does not suggest any means of preventing them. That was one thing I called attention to when my paper was before you. There is nothing new brought forward except the precautions that were being taken.

The President: Practically everything had been tried before the subject was brought before the Society. In many of the bore-holes even now the gas is flushing off under pressure, often bringing out handfuls of fine coal.

Mr. Dickinson: Mr. Gresley seems to ignore the gas altogether in these outbursts which he alludes to.

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SINGULAR NODULES AND ICE-WORN STONES FOUND IN THE BOULDER CLAY OF PIETHORN VALLEY.

Mr. W. Watts, F.G.S., exhibited specimens of the nodules, &c., and read the following notes upon them:—

The nodules found in the Boulder clay on the plains of Lancashire and Yorkshire are as numerous as their structure is variable. Nature does wonderful things, and it is difficult, at times, to distinguish between the natural and artificial objects found in the clays and gravels, especially those known to have been re-assorted by the agency of ice or water.

In carrying out some extensive excavations in Piethorn Valley, about five miles north-east of Rochdale, I have frequently found very interesting, if not unique, nodules embedded in an upper layer of clay associated with burnished stones, of different texture, and beautifully striated. The outer cases of some of them are so fragile that it seems strange that they should be found associated with polished and striated stones known to have been subjected to violent pressure whilst embedded in ice, moving irresistably down the narrow valleys of the Pennine Chain, and often re-arranged in the clayey matrix in which they lie.

One of the nodules is perfectly hollow and empty of the matrix which once filled it, and not unlike a semi-oblate skull, minus the brains, made clear by the workman's pick having accidently struck into it. Another one is similarly pierced, and contains a loose earthy ball which moves freely within, also a number of others in various stages of form and decomposition, all of which possess the same family type, and singular features, and if not unique, certainly uncommon,

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and which I have not seen before. In the main they are formed of limestone, or calcareo-silicious material, having sufficient cementicious matter in them to form an outside case, or skull cap, which protects the earthy ball within.

Others contained an impalpable fine, reddish-coloured mud, which oozed out the moment they were broken, and to which the workmen gave the euphonious name of "blood stones," but which had softer outer cases, showing an absence of cementicious matter to bind them together. The inside of some, however, exhibited no structural features, whilst in others nodular and septarian forms predominate.

The clay in which my interesting nodules were found is generally known as "brick clay," which in this case overlies the typical boulder clay, or till, of the valley, and at least 25 feet in depth. Being near the surface it is subject to weather changes and infiltration of rainwater, which doubtless, has provided the acidulated water to decompose the nodular matrix absorbed by the clay. Whether this opinion will account for the hollow nodules I am uncertain, and submit it for what it is worth. It is hard, however, to resist the idea that this clay bed is not alluvial, and a subsequent deposit to the more typical boulder clay below (and not contemporaneous with it), which fills the earlier contours of the valley, and hides its preglacial, or interglacial features.

The stony character of the clay generally is significant. Foreign as well as local stones are found in it, and at a depth of 12 feet, in one place, two Millstone Grit blocks, about a ton weight each, remnants of the weathering back of the Kinder Scout Grits, reposed on Blackstone Edge, two miles away. I have no doubt these blocks were ice-borne, as the mountain streams in this valley are not strong enough to remove such silent witnesses of glacial

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time and leave the clay in which they are embedded behind, in a valley sloping to the sea.

There are few places on the south-westerly slopes of the Pennine chain more rich in glacial deposits than Piethorn Valley. The clay is thoroughly typical, the boulders are large and numerous, and have a wide distribution, and several species of fossils from the Lias, and Mountain Limestone, have been found in it. I have in my cabinet several small ice-worn stones of special interest to glacialists. Indeed, I am not sure whether I have not amongst them a small Celt of an unusual form and shaped like a double-edged axe, but no trace of a haft-hole remains, although it is thicker in the middle where it should be. It is finely polished and striated, and has the appearance of having been used. If primitive man did not form it, it is much like his handiwork, and deserves to be regarded as a work of art. Another specimen is much like a Liassic *Plagiostoma giganteum*, polished and nicely striated, and swelled out at the *umbo* ike a real fossil specimen.*

Fossil corals are fairly numerous as regards number and species, and, in the main, well preserved, considering by what means they were transported here, and I am not sure whether some of my "finds" are not rare in the Lancashire drift bordering the Pennine Chain.

Two polished and striated limestone pebbles are worth notice. They are burnished much like a glass bottle, and had they been polished by man the gloss could not have

* I have submitted these specimens to Mr. De Rance, F.G.S., and to Mr. Kendal, F.G.S., and they agree with the explanations given by Mr. Dickinson. Mr. Kendal calls them "box nodules," and declares them common in some localities, but they are rare in the Pennine Valleys, and have been case hardened since they were deposited in the clay. Box nodules are usually found in the grits, and are not cased.—W. W.

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been better, or looked more real, and one can hardly help thinking that they may have been used by him in some way or other.

In reference to the gloss, I have seen something like it on flints, supposed to be the tracks of worms, leaving in their path a coating of slime subsequently hardened into a siliceous film. I do not believe this idea, but it is a suggestive one and worth further enquiry, and, if possible, to ascertain why pebbles which lie side by side of similar texture and structure are in one case polished and in the other unpolished.

I do not regard my remarks as a treatise on the Piethorn boulder clay, or the nodules found in it, but as stray notes on the subject, and as such I submit them to the Geological Society of Manchester.

Mr. Stirrup said: I beg leave to move a vote of thanks to Mr. Watts for his interesting paper, and his exceedingly interesting collection of stones and so-called implements from Piethorn. The specimens are all from the Boulder clay, I suppose?

Mr. Watts: Yes, all within an area of about 40 yards; what we call our puddle-field.

Mr. Dickinson seconded the vote of thanks, which was duly passed, and acknowledged by Mr. Watts.

Mr. Stirrup, referring to the hollow nodules, asked if the material found inside them was entirely different from the outside.

Mr. Watts: Yes, entirely different. I allude now to what the workmen call blood-stones. In some cases the

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liquid contents, after oozing out, will flow a foot or 18 inches along the ground. It is most singular.

The PRESIDENT: Are they found in abundance?

Mr. WATTS: Yes, they are fairly abundant. In excavating, whether delving or cutting, we do not get the whole of them. Many are broken accidentally; the men cannot see them, and if a pick strikes one it is broken.

Mr. DICKINSON: There appears to be four different kinds of stone in this exhibit by Mr. Watts. There is, first, this cake (referred to by Mr. Watts as resembling a *Plagiostoma*) which I have no doubt, in my own mind, is simply a cake of clay ironstone. Next, this little diamond-shaped stone which Mr. Watts thought exhibited the work of man, is also, I believe, a piece out of a thin bed of ironstone. Any of you who are conversant with the South Wales ironstone mines will know many of the thin beds are of this diamond form; it is quite common in the South Wales coalfield. Then, the next that Mr. Watts called coral—I should like to know whether this might not be a pholas boring.

Mr. WATTS: No, a pholas boring is quite a different structure.

Mr. DICKINSON: Then, as to the fourth exhibit—the pebbles or small boulders which are quite hard on the outside and are wasted away in the inside—some of them being perfectly hollow. These, to my mind, can have been formed only in two ways. First, the stone itself externally must have been subjected to some action which has, as it were, changed the nature of the external coat, as in the case of lime acting upon wood, producing a kind of petrifaction, whilst the inside has remained in its orginal state and has eventually decomposed away. That is one way in which it

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may be explained. The other is what I mentioned at meeting at which, I think, Mr. Watts exhibited some other curiosities from the same district. It was, I pointed out, a common belief among the men who broke road-stones that to break boulders was very much harder work than to break quarry stone; and I suggested that many of our pebble beds may have been formed in some different way than from the action of water only. If they have been formed in a different way from the ordinary quarry stone then the outer coat may naturally be harder than the inner part. That would account for the outer coat remaining whilst the inner material has gone.

Mr. Watts: All these things have been brought into this bed of clay—they have not grown there naturally, so to speak. They owe their existence in the matrix where they were found to some external force, whether water or ice. With regard to this diamond-shaped stone the explanation given by Mr. Dickinson seems very feasible. But I should like to know how it has received the striations which appear upon it, and why, at one or two places, you find little chips taken from what may be called the cutting edge.

Mr. Dickinson: It has been carried about with the drift; that is what has caused the striations. But these hollow stones are remarkably curious.

Mr. Watts: The formation of a nodule of that kind is different from the formation of a boulder.

Mr. Stirrup: There is no doubt, with regard to the specimen described by Mr. Watts as coral, that it is so. The internal filling of these curious hollow nodules appears to be sand; but how that external covering has been formed is a difficult matter to explain.

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Mr. WATTS: My impression is that whatever the central core may have been it has had an affinity for the substance which has caused the outer shell to be formed.

Mr. STIRRUP: Is there a sandy deposit where these have come from?

Mr. WATTS: No, it is a clay deposit pure and simple. We have no sand. Mr. Watts drew on the blackboard a diagram of the Piethorn Valley, showing the position of the Boulder clay, which, he said, is 20 feet thick. Above, they have a kind of clay ledge on the slope of the valley, and it is in this particular bed of clay that the nodules and other objects exhibited were found.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XXII. SESSION 1893-94.

The ORDINARY MEETING of the Members was held on Tuesday, December 12th, 1893, at the Rooms of the Manchester Literary and Philosophical Society, George Street,

The President, Mr. W. SAINT, H.M.I.M., in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society.

Mr. EDWARD GARSIDE, B.Sc., Civil and Mining Engineer, 6, Chester Square, Ashton-under-Lyne.

Mr. JESSE WALLWORK, Bridgewater Trustees' Collieries, Worsley.

Mr. JOHN ASHWORTH, Civil and Mining Engineer, 8, King Street, Manchester.

Mr. ALFRED BRAMMALL, Outwood Colliery, Stoneclough, near Manchester.

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The Honorary Secretary (Mr. STIRRUP), presented to the Society, on behalf of the author, M. Martel, various pamphlets recently published by him in France on his recent underground explorations in that country. He moved that the thanks of the Society be given to M. Martel for his gift.

The motion was seconded by Professor BOYD DAWKINS, and passed.

BITUMEN FROM A COAL SEAM AT POYNTON, NEAR STOCKPORT.

Mr. G. C. GREENWELL, junr., exhibited and made some remarks upon a lump of bitumen from a coal seam at the Poynton Collieries. It was, he said, found in a small fault at the top of the seam. The block was broken up, and the piece exhibited was the largest preserved. He did not know that bitumen was of rare occurrence in the coal measures, but he had not himself met with anything of the kind before this, nor did he know of its being found in this immediate district. He thought it might be of interest to the Society to mention it. (Mr. Greenwell exhibited a section of the seam (*see next page*), showing the exact position in the 1ft. 9in. Coal in which the substance was found.) The block before being broken up was about two feet long by ten inches high and six or seven inches thick. It was lying close up against the edge of the fault, and on the dip side of the fault. The curious thing is that it is not in the neighbourhood of any large fault. This is only a downthrow of about a foot. Nothing of this kind has been seen in the colliery before, nor anywhere in the neighbourhood.

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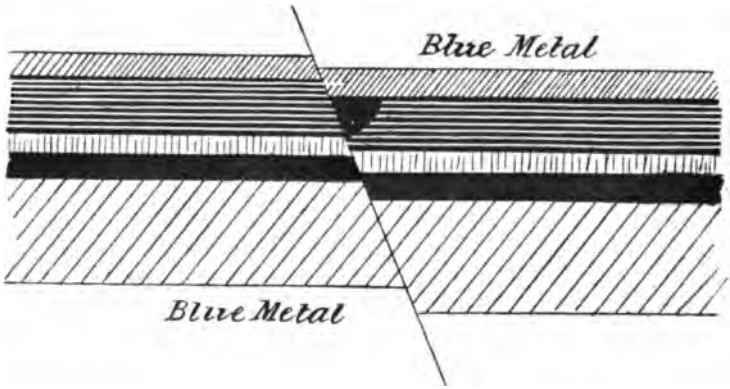
Section of Reform or Waterloo Mine, at the Park Oval Pit, Poynton and Worth Collieries.



Section of the Coal.

Description.	Thickness. Ft.	In.	Ft.	In.
Blue Metal	—			
Black Metal, with Ironstone....	1	0		
Coal	1	9		
Band..	0	10	3	4
Coal	0	9		
Fireclay	4	0		
Blue Metal	—			

The Reform or Waterloo Seam lies about 125 yards above the Redacre Seam, which is supposed to correspond with the Arley Seam in Lancashire.

Depth from surface about 200 yards, and about 85 yards below the Five Feet Seam.

Rise about 1 in 5 nearly due East.

Mr. De Rance asked what was the thickness of the fissure of the fault, and whether the material with which the fault was filled, was, in the opinion of the author, impermeable?

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Mr. GREENWELL: There was no filling up at all. It was merely what we call a slip—as if the coal had slipped down—almost a smooth surface.

The PRESIDENT: Was there any indication of heat?

Mr. GREENWELL: None at all, as far as I could gather. I did not see the place myself. In reply to Professor Dawkins, Mr. Greenwell added that a yard or two below the fault the coal was reported to be of inferior quality, but on the rise it was good, right away up to the fault.

Mr. DE RANCE: The object of my question was to ascertain whether it was possible that water coming, from the surface down the plane of the fault, could have come in contact with certain materials with which chemical changes could have taken place, resulting in the combination occurring. Is there a shale roof, for instance, which would be impermeable and water-tight, prohibiting the idea that whatever change had happened at that particular horizon the materials forming this substance could not have been brought along the plane of the fault from the strata above?

Mr. GREENWELL: At the top of the seam there is a foot of almost black metal, full of iron stone, and above that is a sort of greyish blue metal.

Mr. DE RANCE: So that, practically, it would be a water-tight top?

Mr. GREENWELL: It would be practically water-tight. I have brought a section showing the whole of the seams of the colliery: it will enable you to see the position more clearly.

Professor DAWKINS: I am very glad indeed that Mr. Greenwell has brought this matter before us. I have long been acquainted with the fact that in the coal pits in this district there are various kinds of hydro-carbons, sometimes very much like petroleum, at other times it tends to a waxy material like the elastic kind of bitumen which occurs in such quantities at Windy Knoll, near Castleton. I have

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found this bituminous material (I would not like to take upon myself to say that it is chemically bituminous) in the chambers of some of the goniatites. The discovery of this substance in a seam of coal is extremely interesting to me, because it was the discovery of a similar block in the chalk by Mr. Godwin Austen many years ago, near Dover, that was one of the strong indications to me of the existence of coal measures down below. I have no doubt that the material is the result of condensation by heated gas or liquid, and I think it is very likely that the fault was the cause of the local development of heat. It does not at all necessarily follow that this particular bituminous material was formed from the coal close by; it might travel in a gaseous or liquid condition till it came to the spot where it would lodge and consolidate into the shape in which it was found. The find is an exceedingly interesting one; and I would ask the Society to note one thing—that apparently the mass was lodged on a specimen of lepidodendron, and the cast of the lepidodendron is clearly shown on the surface of the bituminous material. I believe it is Mr. Greenwell's intention to present this specimen to the museum.

The vote of thanks was unanimously passed.

PRESENTATION OF FOSSILS.

Per Mr. George Wild.

The specimens I have the pleasure of laying on the table are the gift of Mr. Robert Cairns, of Hurst, Ashton-under-Lyne, to the Tabulation Committee appointed by the Society. Mr. Cairns very generously placed the whole of his collection of coal-measure fossils before me to select from them whatever I might for the purpose the Society had in view, viz., an attempt to tabulate, in the interests of science and coal-

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mining, the fossils of the Lancashire coalfield with their horizons, where possible, in the strata composing it. I feel sure the Society cannot be too thankful to Mr. Cairns for his liberality, and I hope that his example may be followed by other collectors either as loans for description and tabulation, or gifts of duplicates, or, what is much better, submit the whole for selection, as has been done in this case.

I will not attempt a scientific description of the collection before us, as that is beyond my power, and must be left to more capable scientists, but will simply give a list of them, in such a general manner, that the ordinary reader may form some idea of what may be done by a careful collector, in clearing up, not only scientific but also practical problems in mining, by a little close attention, in his spare moments, to the shales and rocks sent to bank from the sinking of shafts or other excavations.

LIST OF FOSSILS PRESENTED BY R. CAIRNS.

No.	Genera.	Species.	Parts.	Locality.	Horizon.
1	Cœlacanthus	....	Scales	Ashton Moss Colliery ..	The horizon of the Ashton Moss fossils is uncertain, but is probably from 400 to 440 yards for most of them.
2	,, ...	....	Plate	,, ..	
3	Palœoniscus	....	Body, &c.	,, ..	
4	,, ...	....	,, ...	,, ..	
5	,, ...	....	Tail portion ..	,, ..	
6	,, ...	....	,, ..	,, ..	
7	,, ...	....	Body, &c.	,, ..	
8	,, ...	....	Tail portion ..	,, ..	
9	Diplodus.....	gibbosus ..	Tooth.....	,, ..	
10	,, ...	,, ..	,, ...	,, ..	
11	,, ...	,, ..	,, ...	,, ..	
12	Rhizodus	....	Scale	,, ..	
13	,, ...	granulatus.	Jaw and scales.	,, ..	
14	Palœoniscus	....	Scales	,, ..	
15	,, ...	....	Jaw with teeth	,, ..	
16	,, ...	....	,,	,, ..	
17	Cladodus.....	.. .	Tooth.....	,, ..	

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No.	Genera.	Species.	Parts.	Locality.	Horizon.
18	Cladodus.....	....	Tooth.....	Ashton Moss Colliery ..	
19	Diplodus.....	gibbosus ..	,, ...	,, ..	
20	Rhizodopsis	....	Jaw with teeth	,, ..	
21	Strepsodus	....	Tooth.....	,, ..	
22	?	....	Bones & spines	,, ..	
23	Pleurodus	Rankinii ..	Tooth	,, ..	
24	,, ...	,, ..	,, ...	,, ..	
25	Ctenoptychius ..	apicalis....	,, ...	,, ..	
26	,, ..	,, ..	,, ...	,, ..	
27	,, ..	pectinatus .	,, ...	,, ..	
28	Acanthodes	,, ..	Spine.....	,, ..	
29	Amphicentrum or Platysomus ...	granulosum	Head and body	,, ..	
30	,, ..	,, .	,,	,, ..	
31	,, ..	,, .	Scales	,, ..	
32	Cyracanthus ...	....	Spine.....	,, ..	
33	Ctenacanthus....	....	,, ...	,, ..	
34	Megalichthys....	....	Tooth, 2 spines	,, ..	
35	,, ...	....	Vertebræ	,, ..	
36	,, ...	....	Portion of jaw with teeth..	,, ..	
37	Pleurodus	affinis	Tooth.....	,, ..	
38	Megalichthys....	....	Small jaw....	,, ..	
39	Lingula	....	Shell	,, ..	
40	Discina	....	,, ...	,, ..	
41	Megalichthys....	....	Tooth	Dukinfield Colliery ..	Cannel Seam
42	Strepsodus	....	,, ...	,,	,,
43	Rhomboptychius.	....	,, ...	,,	,,
44	Bone portion of large scapula..	....	....	Bardsley Colliery ..	Stubbs Mine
45	Orthoceratite....	....	Shell	River Tame, Dukinfield	Marine Shell Bed.
46	Aviculopecten ..	fibrillosus..	,, ...	,,	,,
47	Trigonocarpon ..	olivœformis	Fruit.....	Broadoak Colliery, Hurst	Peacock Mine.
48	,, ..	,, ...	,, ...	,,	,,

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Many of the specimens are interesting both as regards their rarity in the locality and their state of preservation. Specimens of fish so nearly entire as Nos. 3, 4, 29, and 30, are seldom met with in this part of the coalfield. They are, however, met with in the roof of the Worsley four feet coal at Pendleton, according to the late Mr. Binney's paper in the Transactions of this Society, and whether their horizon should agree with that position it is impossible, with our present knowledge, to determine. The Lingula and Discina are pretty and extremely rare so high up in the coal-measures.

The Trigonocarpons from Broadoak are in the best state of preservation, and most natural form of any I ever met with in the ordinary coal shales of this or any other district.

I conclude with proposing that the thanks of the Society be given to Mr. Robert Cairns for his interesting donation.

Mr. Wild, at the close of his paper, moved that the best thanks of the Society should be given to Mr. Cairns.

Mr. Stirrup said: I rise to second the vote of thanks to Mr. Cairns for this valuable donation of fossils, which is due to the circular which was sent out some time ago to the members and other gentlemen who were thought would be able to assist in getting together a collection which would illustrate the local coalfield; and Mr. Cairns very generously placed these, through his friend, Mr. Wild, at our disposal. Their destination is the Owens College, where I hope they will be taken charge of and kept so that any of our members who may wish to study them can have opportunities of doing so. After the verification of the names given to these specimens by some recognised authority, the collection will then be an extremely valuable one for reference. We hope at some future time to be able to draw up a more complete and authoritative list of the Lancashire Coal Measure fossils than any at present existing. Besides thanking Mr. Cairns, I think our thanks are also due to

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Mr. Wild for having carefully gone through the specimens and given us what information he could respecting them.

The motion was passed unanimously, the President remarking, in putting it to the meeting, that if other members would keep their eyes open and collect similar fossils they would aid materially in the work which the Committee had undertaken.

Professor DAWKINS: I should like to say a few words on this addition to our collection. And when I say "our" collection I use the term advisedly, for I speak on behalf not only of the Manchester Museum, Owens College, but also of the Geological Society. I am glad to say that our collections are rapidly arriving at an importance which I certainly never anticipated some years ago. Within the last two or three months we have added to them Sir Ughtred Kay-Shuttleworth's collection, which is a remarkably magnificent collection, and one of the best, I suppose, in this country; and now we have this collection given us by Mr. Cairns, which certainly is of very great importance from every point of view. Just casually glancing at it I see one thing which will be a very important addition to our museum, namely, that cardiocarpum form which is one of the most obscure fruits of coal-measure times. The marine fossils, too, from the middle coal measures, are to my mind of very great interest. I should not be surprised when that marine bed comes to be worked out, as I hope it will be all over Lancashire, that it forms a definite horizon, in association with the gannister. Therefore, I really welcome these things. I hope the members of the Manchester Geological Society will fully understand that the placing of these specimens in the Owens College is really for the good not merely of the College itself, but of the public; all we can do to facilitate research or make these collections accessible to the members of the Geological Society I need hardly say will always be done.

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ON THE BORING FOR COAL ON THE FREEHOLDERS' ESTATE AT HAZEL GROVE.

By Mr. C. E. De Rance, Asso.Inst.C.E., F.G.S., &c.

In my last communication to this Society, I was able through the courtesy of the directors of the Salt Union Limited, to present the results of their spirited attempt to reach the Coal Measures at Marston, near Northwich, which though commercially unsuccessful, was caused to be so, by geological conditions previously unknown, and disclosed by the bore hole, viz., that the site of the salt lakes in which the rock salt beds of Cheshire were formed, was traversed, by a contemporaneous axis of subsidence, commencing at least, in the Upper Bunter period of the New Red Sandstone, the whole of the strata passed through being thicker than in any other area of the English Trias.

To-day, through the similar courtesy of the Manchester Freeholders' Company, I have the pleasure of bringing before the Society the results of their trial boring for coal, on the boundary of their Bramhall Estate, near Hazel Grove Station, on the Stockport and Buxton branch of the L. and N.W. railway, which happily there is every reason to believe will not only justify the expenditure incurred, but materially add to the prosperity of the district owned by the Freeholders' Company, and of Lord Newton, the boring proving the Hazel Grove portion of both properties.

On the 6th of December, 1890, I suggested three sites on the Bramhall Estate as suitable for trials for coal, the first being that adopted by the directors, it is a source of satisfaction to me to learn that on the 6th of December last, three years afterwards, a four-feet coal has been proved, at a workable depth, and the directors of the Freeholders'

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Company and Lord Newton are to be congratulated in having solved the problem as to the extent of the so-called "Red rock fault," the belief in the great vertical displacement of which has acted most injuriously in checking exploration under the red rocks of Cheshire.

It is worthy of note, that the late Mr. Binney, in 1841, Vol. I., of the Transactions of this Society, page 48, states: "There can be no question of the Upper New Red Sandstone running up on the eastern side to Mr. J. Andrews' works, near Smedley Old Mill, Levenshulme, in a line near by the north, and quietly resting on the basset edges of the coals," pointing clearly to overlap, and not faulting, in an area a few miles north of the district under consideration, and bounded by the same fault. Again (page 51), he says:—"I call the point where the New Red Sandstone formation abuts against the Coal Measures *the fault*, for the exact line of the dislocation in the latter strata we can never hope to determine, since its edges have been worn down and afterwards covered with New Red Sandstone."

My former colleague, Professor Hull, LL.D., F.R.S., gives an interesting note, in Appendix II., of the Geology of Stockport, Macclesfield, Congleton, and Leek, published in 1866, in the Memoirs of the Geological Survey, stating the results obtained by experiments made on Lord Vernon's property at Poynton, a horizontal tunnel was driven westward, from the Park Pit, at a depth of 200 yards from the surface, after crossing the four feet coal, and at a distance of 437 yards, a large downthrow fault was passed through, and reddish shales and grits, dipping west entered on the opposite side. Eventually smaller faults were crossed, and a three feet coal was reached unknown in the Poynton district. The faults, Professor Hull states, may or not be the "Red Rock Fault," but it has very marked effects, the ironstones being altered as to resemble jaspers, the shales burnt, the four

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feet coal reduced to a cinder, and the whole of the beds indurated and abnormally hardened.

In my report of the 6th December, 1890, I estimated the thickness of the Permian rocks in the Bramhall area as probably not less than 850 feet; they have turned out to be 913 feet, or 63 feet thicker than I estimated, a difference which, looking to the variable nature of the Permian rocks, was not unexpected.

The following is an abstract of the beds passed through:—

					Feet.
Drift					80
Pebble beds of the Bunter					30
Permian marls and sandstones					913
		ft.	in.		
Measures, chiefly red		471	7		
Coal and shale mixed		2	0		
Dark shale, ironst. nodules		11	5		
	ft. in.				
Coal	1 5	2	2	.....	602
Parting	0 2				
Coal	0 7				
Measures, dark or grey		110	10		
Coal		4	0		

It is worthy of note that the red and variegated beds extend down to within three feet of the two-feet coal and shale; that this bed and the two-feet coal below it have shale roofs; that all beds below are dark or grey; that 20 feet of close grained sandstone overlies the ten-feet shale, which rests on the four-feet coal.

The boring has been carried out by Mr. Thom, Canal Works, Patricroft, the portion in the red rocks was carried with a slack rope and free fall, the remainder by means of the Diamond. The dip of the shale has varied from seven to eleven degrees.

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TRIAL BORING AT HAZEL GROVE.

Ft.	In.		Ft.	in.	Ft.	in.
1	6	Surface soil			1	6
6	0	Blue clay			4	6
11	0	Sandy clay			5	0
16	0	Loam			5	0
25	0	Sandy clay			9	0
30	0	Blue clay			5	0
42	0	Loam			12	0
47	0	Brown clay			5	0
54	0	Sand and gravel			7	0
60	0	Clay and stones			6	0
70	0	Sand and gravel			10	0
79	0	Clay and gravel (Base of Drift)			9	0
110	0	Sandstone with quartz pebbles (f.2)			31	0
			Ft.	in.		
138	0	Quicksand	28	0	30	0
140	0	Sandstone	2	0		
257	0	Marls (sandy)			117	0
704	0	Sandstone—soft	447	0	639	0
880	0	Sandstone—hard (close grained)	176	0		
883	0	Red marl	3	0		
896	0	Hard sandstone (like above)	13	0		
1000	0	Red marl			104	0
1017	0	Sandstone (very hard)			17	0
1019	0	Marl with gravel			2	0
1023	0	Red marl (Base of Permian)			4	0
1248	0	Variegated marls, pink and ashy grey (Coal Measures)			225	0
1257	3	Bind or indurated sandy marl (purple)			9	3
1257	7	Sand and clay (dark red)			0	4
1258	4	Shale, slate coloured			0	9
1267	0	Red and grey marl			8	8
1337	0	Indurated sandy marl (purple)			70	0
1352	0	Variegated shales with ironstone balls			15	0
1372	3	Red marl			20	3
1392	9	Red and grey sandstone and sandy shales			20	6
1414	4	Variegated sandy shales with bands and balls of Ironstone			21	7
1420	4	Red and grey sandstone			6	0
1432	4	Variegated sandy shales with ironstone balls			12	0

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			Ft.	in.
1434	1	Dark shale	1	9
1436	4	Red and grey shale with ironstone balls	2	3
1448	4	Blue shale with ironstone bands and coal in joints	12	0
1451	4	Very dark shale with ironstone balls	3	0
1453	4	Variegated shale	2	0
1460	4	Red and grey sandstone	7	0
1471	10	Variegated shale with ironstone bands	11	6
1478	4	Red and grey sandstone and sandy shale	6	6
1479	4	Variegated shale with ironstone bands	1	0
1480	10	Red and grey sandstone	1	6
1481	1	Red shale	0	3
1481	6	Dark sandstone	0	5
1491	7	Red and grey sandstone and sandy shale with ironstone bands	10	1
1494	7	Dark sandy shale	3	0
1496	7	Coal and shale mixed	2	0
1508	0	Dark shale with ironstone bands	11	5
1509	5	Coal	1	5
1509	7	Parting	0	2
1510	2	Coal	0	7
1511	6	Warren earth	1	4
1521	0	Dark shale with ironstone bands	9	6
1523	0	Grey sandstone with fireclay joints	2	0
1526	0	Light grey sandstone (close grained)	3	0
1535	0	Dark grey bind	9	0
1536	6	Dark grey sandstone	1	6
1540	6	Dark bind	4	0
1546	6	Dark grey sandstone (close grained)	6	0
1556	0	Dark shale with ironstone bands	9	6
1556	6	Black shale	0	6
1563	0	Dark shale with ironstone bands and balls	6	6
1574	4	Dark sandy shale	11	4
1575	3	Dark sandstone	0	11
1594	8	Dark sandy shale with ironstone bands	19	5
1611	4	Grey sandstone (close grained)	16	8
1622	10	Dark shale	11	0
1623	10	Coal	1	0
1624	2	Parting stone	0	4
1627	3	Coal	3	1
1629	1	Warrant	1	10
1631	7	Light coloured sandstone	2	6
1633	2	Slate coloured shale, ironstone nodules, "Gannister-like" rock	1	7

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Denton and Hyde.	ft. in.
Sod Mine (bad)	5·8
Measures	99·0
Coal	1·7
Measures	33·0
Strata	189·0
Bog Mine (good)	6·0
Strata	96·0
Roger Mine (good).. ..	5·6
Strata	84·0
Double Coal	9·0
Strata	414·0
Hard Mine (good)	4·6
Strata	204·0
Town Lane	3·8
Strata	30·0
Top Shotties	2·4
Strata	144·0
Lower Shutch..	2·8
Strata with *red* rock ..	615·0
Saltpetre coal	5·0
Strata	120·0
Black Mine (good)	4·6
Strata	24·0
Coal	·10
Strata	27·0
Coal and dirt	2·0
Strata	105·0
Stone Mine (1in. parting).	3·3
Strata	45·0
Upper Bent	1·4
Strata	96·0
Peacock coal	2·6

Hazel Grove.	ft.	in.
Possible correlations.		
Strata, *red* & variegated	471	7
Coal, with 11 ft. parting	4	2
Strata	110	10
Coal	4	1

Mr. Gerrard said: I have very great pleasure in proposing that we give to the Freeholders' Company and Mr. De Rance our hearty thanks for the valuable communication which has just been placed before us. I hope we

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shall have an opportunity of carefully considering these sections, before the subject is discussed, in order that we may be the better prepared for entering upon the discussion.

Mr. GREENWELL: I have pleasure in seconding the vote of thanks. Personally I shall be very pleased if an opportunity is given for discussion of the paper at some future time. It is a most interesting one to us all, and especially so to me who have to do with a neighbouring district.

The vote was unanimously passed.

ON THE IRON ORE MEASURES OF COUNTY ANTRIM.

BY MR. G. H. KINAHAN, M.R.I.A., &c.

It was the intention of the late Mr. Walter Jameson to lay before the Society a descriptive account of the *Iron Ore Measures*, County Antrim, but his lamentable and sudden death prevented him. Your Honorary Secretary on this account has asked me to do so, which I shall attempt, but much regret it cannot be as exhaustive as if written by Mr. Jameson. Before commencing, it should be mentioned that in recent years the subject has been considered in a paper by Mr. P. H. Argall, *On the Tertiary Iron Ore Measures, Glenariff Valley, County Antrim.*—(Proc. R.D. Soc., Vol. III. New series, pp. 151 *et seq.*)

In a paper by the writer "*On some of the Irish Crystallian Iron Ores* (*ibid* Vol. IV., 1885, pp. 310, *et seq.*), and in the *Economic Geology of Ireland.*—(Proc. Royal Geo. Soc., Ireland, Vol. VIII. New series, pp. 65, *et seq.*)

These Iron ore measures are a subordinate group in the Eocene Dolerytes of the County Antrim, and when fully

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represented, according to Mr. Argall, they consist of the following:—

8. Lignyte.
7. Alumyte or alum clay.
6. Steatitic clay. (*Holing.*)
5. Steatitic rock. (*Brushing.*)
4. Pisolitic or pebble ore. (*First ore.*)
3. Bole or aluminous ore. (*Second ore.*)
2. Ochreous rock. (*Pavement.*)
1. Lithomarge. (*Lateryte with inliers of bole.*)

In explanation of the local terms, Nos. 6 and 5, Mr. Argall states No. 6 is soft stuff that is removed or "holed" to give room for the ore to be raised by blasting, while No. 5 is a scaly rock, which if left would drop into the workings, these scales therefore are cleared or "brushed" away. Both these beds are more or less altered portions of the lower portion of the overlying doleryte bed (roof).

The Iron ore measures appear to have been in part lacustrine deposits, which accumulated in shallow lakes or ponds of water in hollows, on the ancient surfaces of the lava sheets, to be subsequently covered up by newer sheets of lava.

The *Lithomarge* is in part a methylotic rock, as it is usually more or less steatitic. Its origin was probably muds, formed from the weatherings of the exposed surfaces of the doleryte; its constituents having been carried into the lakes and pools by rain, runlets and, in a great measure, by the wind. In it there are beds and lenticular masses of bole, sometimes rich enough to be worked as iron ore. The normal lithomarge represents the wash of continuous rains, or the drift of continuous or heavy winds; while the beds of bole may be the residue left when pools of water evaporated during long periods of drought. It is, however, possible that they had another origin, to which we will refer hereafter. In places in the lithomarge are blocks of

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doleryte with the outer parts decomposed to various depths; as these often occur at some height above the base of the accumulations they are hard to be accounted for; and I have had some enquirers, among others the late G. A. Kinahan, to contest the above theory of the lithomarge being a sedimentary rock; they suggested that it is a methylotic doleryte formed *in situ*. In favour of this theory they point to the blocks and the amygdaloidal portions. The latter, however, are at the underlying surfaces of the doleryte; and such an origin would scarcely account for the inlying beds of bole, unless the boles are secondary accumulations, as will be hereafter mentioned.

The writer suggested to Mr. Jameson that the lithomarge combined with the chalk ought to be capable of being manufactured into a cheap and effective hydraulic cement. This idea he took up, and made experiments that were most successful; but at the time he had too many irons in the fire to embark in an additional adventure, as the required plant, etc., to carry it out would necessitate a large preliminary outlay. He hoped, however, that at some future time he would be in a position to start this new industry. His untimely death has, however, prevented him doing so. I have to regret that his letters on the subject have gone astray and cannot be quoted, as such an adventure ought to pay. As this subject is an important one, perhaps I may be allowed to diverge, and go more fully into it. It is now well known that artificial cements are much superior to natural ones; as the latter, according to the varying nature of the cement rocks, cannot be of one uniform standard; while an artificial cement may be made of an uniform standard, *if it is made in large lots*, and these lots are blended so that all the stuff put on the market is of equal excellence. This, however, necessitates a considerable capital, as thousands of tons must be in stock before the

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blending process is commenced, as otherwise, if a large contract is taken up, the stuff supplied not being properly tested will probably not be up to sample. This was one of the principle reasons why Mr. Jameson did not embark in it.

At the margin of the waters in which the lithomarge was accumulated, bogs grew which are now represented by the lignyte. These vegetable accumulations leached the iron out of the associated lithomarge bole, etc., leaving as a residue the alumyte, or alum clay. The value of the alumyte was first discovered by Mr. Jameson in 1873, who began to work it in 1874. At the present time, only this clay is worked for the manufacture of alum, but apparently the lithomarge and the bole might also be utilised, as they are more or less similar in aspect and composition to the German *Woeheinyte* and the French *Bauxyte*. The latter name for some unaccountable reason has been given by the Government officers in their official returns, to the Irish alumyte, although the minerals are conspicuously different; as will be seen by the following analysis, procured through Mr. Jameson.

	Alumyte, Glenarm.	Alumyte, Ballintay.	Bauxyte, Dahm's.	Bauxyte, Margrilleo.	Woeh-einyte.
Alumina	42·5	52·37	63·19	67·83	57·04
Peroxide of Iron ..	1·54	1·29	3·72	00·47	1·08
Lime	0·46	0·48	..	..	..
Magnesia	Trace.	Trace.	..	..	.
Potash and Soda ..	0·04	0·06	..	..	..
Silica	27·50	12·15	11·47	10·64	19·60
Titanic Acid.....	9·40	5·20	..	..	..
Sulphuric Acid ...	0·08	0·35	..	..	..
Phosphoric Acid ..	None.	None.	..	..	..
Organic Matter...	Trace.	Trace.	..	..	..
Combined Water..	18·53	27·13	16·32	15·80	17·45
	100·00	100·00			

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The analysis of the alumyte was made by John Pattison, Newcastle-on-Tyne. The alumina is both hydrated and anhydrous—as sulphuric acid in the process of alum making, only extracts the hydrated alumina; in the continental minerals by all known processes, there is a loss of from 6 to 8 per cent. that cannot be extracted; on this account the Irish clays compare much more favourably with the continental than this Table suggests—(see the French and German analyses). Many of the bauxytes and woeheinytes contain much more iron than the above, one variety of the latter having been smelted as an iron ore.

Of Bauxyte, Dana gives three analyses; containing of iron respectively 27·0, 3·0, and 34·9 per cent. The Irish clays contain much more silica than is found in the French or German. Dana's bauxyte, however, which gave only 3·0 iron is white in colour, and gave 21·7 of silica.

It is evident that the lower portion of the lithomarge accumulated first; and afterwards the upper portion was accumulating in the deeper parts, while the vegetable matter was growing round the pools.

The *Ochreous Rock* is the surface portion of the lithomarge, and is called the "pavement" because it is the floor of the iron ores.

A point of considerable interest is that the alumyte was originally lithomarge or bole; its present appearance and character being solely due to the leaching from it of the iron, by its contact with the vegetable accumulation; consequently we do not find alumyte except associated with the lignyte. The late Mr. Jameson's theory as to the formation of the alumyte and associated beds was very similar if not identical with that given above.

Argall states: "The analysis of the lithomarge shows "it to be essentially a silicate of iron and alumina. There-

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"fore as alumyte is a silicate of alumina the dissolving out of "the iron of the bole or lithomarge would change either of "them into alumyte; hence it is highly probable the organic "matter from the decaying shore vegetation (now repre-"sented by the lignyte) dissolved out the iron from the bole "and lithomarge," page 160.

We have next to consider the genesis of the iron ores, and how they accumulated between the lithomarge and the overlying doleryte beds.

It would appear evident that they are younger than the overlying dolerite bed for the following reasons:—First, coming up through the Iron ore measures in the Glenariff mine, as mentioned by Mr. Argall. These are nearly perpendicular dykes, bearing about N. 15° W. (true). They are thus described:—"These dykes may be divided into two distinct classes—first, those which stop at the roof, or *stop dykes;* and, second, those that penetrate the roof, or *through dykes.* The latter invariably displace the ore measures and bake the pisolitic seam; while the stop dykes neither displace nor bake the seam. The dykes that stop at the roof have a steatitic parting separating them from it, similar to that above the pisolitic ore. Some of the *stop dykes* turn over or *splash* against the roof, which goes to prove they are newer than it; while the *through dykes* in general can be traced up to the sheet to which they belong," that is, of which they are the roots. "As already stated, the pisolitic ore is neither baked or displaced by the majority of the dykes that stop at the roof, while it is nearly always displaced and indurated by the dykes which penetrate the roof. From this it would appear that the pisolitic ore was formed prior to the latter and subsequent to the former."

The pisolitic ore has larger pisolites and is richer at the surface, the richness and size of the pisolites decreasing

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gradually downwards till it merges into the bole; the latter is often too poor to be profitably worked. The ore seam (Nos. 3 and 4) is of very irregular thickness, as in places the roof descends until it rests on the *pavement;* or there are hollows and potholes in the latter; or the pisolitic ore may be absent, the roof resting on the bole; or the latter may also be absent.

The above facts seem to conclusively prove that the iron ores occupy a shrinkage fissure due to the lithomarge drying and contracting, and thereby shrinking away from the steatitic base of the doleryte sheet. The following may be suggested as having occurred:—First, there was a system of dykes that ran upwards till stopped by the hard roof of the lithomarge. Immediately afterwards the lithomarge began gradually to dry and contract, while towards the margin of the basin the lignyte in general shrunk away from the alumyte, as between them in places a thin bed of bole occurs. Into the fissure the iron ore, in part in solution, as suggested by Mr. Argall, found its way, but at the same time it must have been considerably augmented by iron, leached out from the lithomarge, during its change into alumyte. We have already mentioned the seams of bole in the lithomarge, and here it may be suggested that possibly they all had their origin in shrinkage fissure, into which iron in solution percolated.

The above would appear a most plausible way of accounting for the occurrence of the iron ore seam, as it lies uncomformably on the *pavement*, while the *stop dykes* are evidently younger than the latter, while they are older than the seam. It is also worthy of note that these *stop dykes* act very similar to the cross courses, heaves, and the like, that occur in connection with standing lodes; as at one side of the dykes the seam is much thicker and richer than at the other. This thickening of a vein at one side of a cross

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course has not as yet been satisfactorily explained, but probably, if we knew it, very similar reasons apply both to the standing and the horizontal lodes. There is nothing new in a horizontal lode, as they are the "lay and lay" lodes described by Henwood, which occur as adjuncts to the vertical lodes in nearly every mineral district all over the world. Henwood, however, if my memory is correct, does not record as large or so continuous horizontal lodes as those of Co. Antrim.

From the facts recorded by Argall in the Glenariff Mines the *stop dykes* act similar to "cross courses" in vertical vein, as on one side the lode is rich, and on the other poor. In these mines the flow of richness was from east, westward, so that on the east side of each "stop dyke" the ore is richer and thicker than on the west side, while the "through dyke" that cut through the ore beds after they were deposited, altered them only.

Argall's conclusions are very similar to those suggested by the writer, except in one important point. This observer considers the whole of the Iron ore measures to be lacustrine accumulations, but at the same time points out "the pisolitic iron seam is not of even thicknesses, and is often absent over large areas, also it thickens at one side of a dyke and not at the other, the pisolitic stratum being well developed in one place and scarcely discernible in another, and the largest pisolitic being always found next the roof, decreasing both in size and number as we descend from it. These are facts difficult to explain in a lake deposit."

These difficulties seem to be satisfactorily explained, if the theory previously suggested and described is correct. That is, the iron ores are secondary adjuncts of the lake accumulation, as they accumulate at a subsequent period, as a true lode, in a horizontal shrinkage fissure; the filling being from below

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upwards, and not from wall to wall as in a vertical lode, the lower deposits being more or less impure, while the highest one was richest in metal.

Those specially interested in the subject may be referred to Mr. Argall's paper for further details.

The thanks of the Society were given to Mr. Kinahan for his communication.

A paper by Mr. C. H. Williams, "On the Mining of the Iron Ores, Bauxite, &c., of County Antrim," intended to be read in conjunction with Mr. Kinahan's paper, was unavoidably postponed till the next meeting.

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MAR 25 1895

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XXII. SESSION 1893-4.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held in the Mining School, Wigan, on January 12th, 1894.

Mr. H. HALL, H.M. Inspector of Mines,
in the Chair.

NEW MEMBERS.

The following gentlemen were unanimously elected Members of the Society:—

ROBERT CLARK, Mining Engineer, 28, Deansgate, Manchester.

JOHN HAYWARD, Ladyshore Colliery, Little Lever, Bolton.

SAM. C. BARLOW, Rock Cottage, Tiviot Dale, Stockport.

The Hon. Secretary (Mr. STIRRUP) said that for the last few years they had been in the habit of holding one of their meetings at the Geological Museum, Owens College, and it had usually taken place about the end of January.

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This year it would be held on the 2nd February, and he was pleased to say that Professor Boyd Dawkins would give an address on "Further Notes of the Coal Borings at Dover," which would probably include all the information obtainable of the progress of the exploration up to the present time. There would also be laid out for exhibition the recent additions to the Museum in the way of Carboniferous Fossils, which would include the recent gift of the well-known collection of Sir U. Kay-Shnttleworth, drawn mainly from the Burnley Coal Field. He hoped the evening would be a very interesting one, and that many Members who lived around Wigan would be present.

The Chairman then called upon Mr. Higson for his promised paper, which was illustrated by diagrams and photographs :—

THE WALKER PATENT "INDESTRUCTIBLE" VENTILATING FAN AND ENGINES, AS ERECTED AT THE PARK COLLIERIES, GARSWOOD; THEIR CONSTRUCTION, ARRANGEMENT, & EFFICIENCY.

By Mr. Charles H. Higson.

The Walker "Indestructible" ventilating fan and engines were introduced some seven years ago by Messrs. Walker Bros., of the Pagefield Ironworks, Wigan, and a ventilating plant of this description having been erected at Messrs. J. and R. Stone's collieries at Garswood, of which I have charge, it has been suggested to me that a description of its construction, arrangement, and efficiency would be acceptable to the members of this Society.

In designing this machinery endeavour has been made to produce an arrangement which, while obtaining a high

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degree of economy and efficiency, should possess freedom from liability to break down, and also sufficient simplicity in its working parts to bring it within the comprehension of the every-day colliery engineman. With this view the engines have been made large enough to perform their duty at a moderate piston speed, and all complicated valve gearing has been avoided. Experience in the construction and working of engines driving ventilating machinery, and, indeed, in colliery engines generally, has shown the advantage of moderate speeds. These engines were designed for a speed of 50 revolutions per minute. This gives a piston speed of 400 feet per minute, which is very moderate when compared with the performances of many engines driving mills; but it is found that the destructive effect lies not so much in the speed at which the piston travels as in the frequency of its change of direction, and that a speed of 50 revolutions per minute is the most advantageous when dealing with engines of the class and size herein referred to.

In the case of mill engines it is usual to run them at much higher speeds; but the difference between these engines and those driving ventilating machinery is that the former work with the advantage of the intervals of meal-times and stoppages during the night and at week-ends, but with fan engines the stoppage is limited, as a rule, to a very brief interval on Sunday mornings, and in some cases even this is not permissible.

Taking the hours worked during a week, mill engines run only one-third the time of fan engines; or, in other words, each year the work done by ventilating engines represents three years' work as compared with mill engines.

The engines are of the twin or side-by-side compound, condensing type—that is to say, there is a crank at each end of the crank shaft, one crank being actuated by the high-

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pressure piston and the other by the low-pressure piston, the driving pulley being placed midway between the two cranks.

The stroke of each cylinder is 4 feet. The diameter of the high-pressure cylinder is 22 inches, and of the low-pressure cylinder 38 inches.

The valves are ordinary slide valves, an adjustable cut-off valve being fitted to the high pressure cylinder. The cut off valve can be regulated while the engines are running and it is intended that the stop-valve should remain at all times wide open, the speed being controlled by the cut-off valve.

A warming valve admits live steam to the low pressure cylinder to warm it before starting and to start the engines when the high pressure crank is on the dead centre.

In Messrs. Walker's more recent engines, adjustable cut-off valves are fitted to both cylinders. This enables the load to be equally divided between the high and low pressure cylinders at all speeds, to meet the varying duty required from ventilating machinery, as in the case of new mines opening out.

By means of a system of valves in the exhaust pipes, either engine may be disconnected and the remaining engine may be worked alone, either condensing or otherwise, and is sufficiently large to develop almost the full duty of the fan when so doing.

A separate steam stop valve is provided to admit live steam direct to the low pressure cylinder when working alone, and a combined reducing and safety valve, reduces the steam pressure in proportion to the increased diameter of the piston and prevents the accumulation of dangerous pressure in the pipes leading to the low pressure cylinder.

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A three way valve on the main exhaust pipe and controlled from the engine room enables the man in charge to turn the exhaust steam into the condenser or into the atmosphere as may be required whilst the engines are running.

The air pump is worked by a drag-crank from the low-pressure crank pin.

Motion is transmitted to the fan by fifteen cotton ropes, each $1\frac{5}{8}$ in. diameter. The grooved driving pulley is 16 ft. diameter, and the driven pulley on the fan shaft is 7 ft. 6 in. in diameter, giving a ratio of one to a little over two.

It is found that these cotton ropes run most satisfactorily at speeds of 3,000 ft. per minute and over, and it is therefore now the practice to increase the diameter of the driving pulley to 20 ft. for engines of this size.

The power which may be safely transmitted by a cotton rope $1\frac{5}{8}$ in. diameter may be taken at about 10-horse power per 1,000 ft. per minute up to 3,000.

In mill practice it is found that the average life of cotton driving ropes when properly treated is about twelve years. The comparatively recent application of these ropes to ventilating machinery renders it impossible to say what their durability is likely to be, but experts say that it will probably exceed that of mill ropes, in consequence of the steady load and freedom from sudden strains.

The method adopted for lubricating the crank pins is a noteworthy feature of the engines.

A cylindrical vessel filled with oil is suspended above the crank pin. A rectangular brass tube passes through the bottom of the vessel and projects above the surface of the oil inside. A number of woollen threads are led from the

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inside of the vessel through the tube, and are allowed to hang downwards from its end.

The wool becomes saturated with oil by capillary attraction, the flow of oil being regulated by a brass plate inside the tube, which may be caused to compress the wool.

To the end of the connecting rod is attached a brass tongue in such a manner as to come into contact with the saturated wool at each revolution, wiping off a certain quantity of the oil, and conducting it to the crank pin. The tongue is faced with flannel to prevent the oil being thrown off by centrifugal force.

The consumption of oil is 1½ pints per week for each crank pin.

When local circumstances will permit of its adoption the "twin" arrangement—that is, placing the high and low pressure cylinders side by side—is much superior to the tandem arrangement, in which the cylinders are placed one behind the other.

By the twin system the inconvenience of dead centres is avoided, as live steam can be admitted to the low-pressure cylinder to start the engines when the high-pressure crank is centered. The driving pulley receives a comparatively light impulse at each of four points in the revolution, instead of receiving a heavy impulse at each of two points in the revolution, and greater regularity and evenness in the running of the ropes is thereby secured. The working parts may be lighter and are more evenly balanced, and an accident, for instance, to a crank pin which could be met by disconnecting the disabled engine and by running the other alone, would, in the case of the tandem engines, lay the fan idle and stop the pits until the damage was repaired.

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The Fan.

The chief points aimed at in designing the "Indestructible" Fan were (I learn from the makers) to produce a ventilating machine which should obtain a high percentage of useful effect without the great weight, unwieldy dimensions or expensive foundations of the large direct driven fans, and which should at the same time possess the strength, rigidity and durability of the smaller fans, whilst avoiding their high speed and consequent frequently heated bearings.

The construction of the fan, which is 24 ft. diameter and 8 ft. wide, and is built up exclusively of iron and steel, is as follows :—

There are two strong cast-iron bosses. These bosses are carefully bored out and made a good fit upon the fan shaft, and are further secured to the shaft by means of steel keys. The bosses extend lengthwise on each side towards the journals, thereby distributing the weight of the fan over a considerable portion of the fan shaft.

Between the bosses are placed two discs of steel, of uniform thickness, bored in the centre to fit the fan shaft.

The bosses, where they come in contact with the discs are turned on the face.

Each disc is in halves, the joints being placed at right angles to each other. By this arrangement the two discs form one disc of considerable strength, much lighter but stronger, than if the disc were in one solid plate.

Between the two discs the iron arms of the fan are fixed "sandwich-like," and are gripped tightly by them. These arms extend from near the axis of the fan to its periphery, being supported half-way by the discs.

The two bosses are secured together by means of turned

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bolts passing into carefully rymered holes; the bolts being lock-nutted, and as these bolts pass through both the discs, the bosses and the fan-arms, the whole structure becomes specially strong.

In the small spaces between the discs which are not filled up by the fan arms, there are inserted annular plates. The whole portion outside the boss is then securely rivetted together.

Angle irons are rivetted to the fan arms where they extend beyond the discs, to these angle irons the vanes eight in number are firmly secured, the cross section of the arm and vane together being like the letter T thus forming a beam of great strength and rigidity. The top of the T representing the vane and the surface pressing against the air. The vanes which spring tangentially from a small circle concentric with the fan shaft are curved longitudinally to the arc of a circle of a certain radius and are cut away from the edge of the inlet to the fan-shaft to minimise central resistance.

The main bearings of the fan are placed in the two inlets of the fan chamber, the distance inside the bearings being only 8 ft. The outer bearing being placed just outside the rope pulley upon the fan shaft. The latter bearing is made with adjustable brasses so that the wear produced by the tension of the ropes may be taken up.

The pedestals are cased all round to prevent access of dust to the bearings.

It is very necessary to minimise the slipping of the air between the sides of the vanes and the walls of the fan chamber as far as practicable. The vanes being strong and of iron cannot be brought close to the walls, as in the event of any side movement of the fan on its bearings the

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vanes might "catch" and be injured. This clearance is, therefore, made up by attaching strips of pliable hoop iron to the sides of the vanes.

The method adopted for obtaining constant lubrication of the fan bearings is worthy of notice. An eccentric upon the crank shaft of the engines actuates a small pump which delivers oil from a tank beneath the floor of the engine-room into one fixed high up against the wall. From this latter tank the oil flows by gravity through pipes communicating with each of the fan bearings, and, after lubricating the journals, is collected by cups fixed to the sides of the pedestals and conducted to the lower tank. Here it is filtered by passing through a sheet of copper gauze, and is again pumped into the upper tank. Constant lubrication is thereby secured, the bearings practically running in a bath of oil. The consumption of oil is 4 pints per week for the three bearings.

The fan is fitted with the Walker anti-vibration shutter.

The history of the invention and introduction of this shutter (for which I am indebted to the makers) is very interesting.

About 1886 Messrs. Walker constructed and erected three Guibal fans for ventilating a portion of the Metropolitan and District Underground Railway.

Those who have had experience with Guibal fans will be aware that as each blade or vane passes the lower edge of the shutter a pulsatory action takes place. When the fans above mentioned were set to work the pulsation or vibration of the large volume of air discharged was so great that it caused a corresponding vibration of the window sashes, doors, &c., of the surrounding buildings, and this was so unpleasant that the professional men and others near

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obtained an injunction against the railway company compelling it to stop one of the fans. The work by this time was out of the makers' hands, and they only casually heard what had taken place, learning, also, that in addition to this injunction another was threatened in the case of the second fan, and that the railway company had thus far escaped the enforcement of this threat by agreeing to run the second fan at a few short stated intervals only during the day.

In considering the case it occurred to the makers to incline the lower edge of the shutter instead of making it parallel with the axis of the fan, by which means it was thought that the waves of air might be broken up or at least reduced. It was, however, ultimately decided to make the shutter like an inverted V, and this was found to be completely successful.

Having thus explained the history of this invention and its utility in removing vibration and consequent noise, we now come to a still more important advantage to be gained by its application. Experience in the working of Guibal Fans proves that fan shafts, even though made unusually strong in proportion to the horse-power transmitted through them, frequently break. In Belgium, the birth-place of the Guibal Fan, the average life of the shafts is found to be from twelve to fifteen years. The breakage of fan shafts, and the loosening of bolts and rivets in fans generally, are to be attributed to the excessive vibration hitherto inseparable from their working. This vibration is caused by the too abrupt cessation of the delivery of the air from the fan vanes or blades as they pass the opening to the chimney, and for this the shape of the regulating shutter or slide is responsible. The upper part of this opening, formed by the shutter, as hitherto constructed, has a line parallel to the tips of the fan vanes, and as the fan revolves these lines

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become identical; the delivery of the air is as a consequence abruptly terminated.

Whilst discharging the air, the pressure is against the front of the vane, but immediately the vane enters the fan casing the load upon it is suddenly removed, and the pressure, owing to the vacuum within the casing, is instantaneously reversed, and a rebound upwards of the previously depressed blade takes place. The effect is communicated throughout the whole of the fan and to the shaft also, and as each blade represents a powerful lever, the momentum of the blow or jerk becomes serious on reaching the shaft and a dangerous tremor or vibration is set up.

As an illustration of the effect of this action let us take the case of a fan constructed strictly on Guibal principles and upon which experiments were made some time ago. In these experiments readings were taken from a water gauge which was attached to the fan casing at intervals from the centre to the periphery, above the shaft. At the centre the water gauge indicated 3 inches, but near the outer edge or periphery it was half-an-inch. The fan was 24 feet diameter and ran at 80 revolutions per minute. Taking the average water gauge over the surface of the blades at 1½ inches it would represent a pressure of 7·8 lb. per square foot or a total pressure on each blade of nearly 500 lb. Assuming the centre of the blade to be the centre of the load, the distance from the centre of the load to the centre of the fan shaft would be approximately, 9 feet. Taking the work of one day of 24 hours, the fan running at 80 revolutions per minute :—eight blades, by 80 revolutions, by 60 minutes by 24 hours = 921,600. This product represents the number of times in a single day that a weight of, at least, 500 lb. is, as it were, instantaneously removed from the blades and the shock resulting from the removal is transmitted to the fan

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shaft. The shaft is thus in a constant state of tremor, and sooner or later reaches its elastic limit. The consequent injury to the general structure of the fan is obvious.

The Walker anti-vibration shutter as attached to the fan at the Park Collieries removes this evil by effecting a perfectly gradual change in the pressure referred to, and so governs the discharge of the air as to cause it to pass, without objectionable eddying in a continuous stream from the fan vanes into the chimney, instead of intermittently, and without the pulsatory action described.

The shutter is constructed in sections, any of which can be removed for the purpose of adapting the area of the opening to varying duties of the fan.

The fan is suspended eccentrically in a volute or spiral chamber.

In the experiments, the results of which are given in the annexed tables, elaborate precautions were taken to avoid error. Each airway was divided by wires into a number of similar and equal parallelograms, and the calculations are based upon the average of several measurements in each parallelogram. The anemometer used had been sent to the makers for adjustment for the purposes of these experiments. A competent person remained in charge of the engines to ensure a constant speed being maintained. The end of the water-gauge tube was fixed at right angles to the current, about half-way between the fan inlet and the pit, and was enclosed in a box filled with cotton waste to avoid false readings through fluctuation of water in the tube. The water-gauge readings were also checked at several points in the fan drift, and found constant.

In the experiments made to ascertain the coal and steam consumption, indicator diagrams were taken from the

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AND ENGINES.

s. In Mine.	Peri-phery Speed, Feet per Minute	H.P. in Air.	Steam Pres-sure.	Cut off in H.P. Cylinder.	Vacum shown on Gauge.	I.H.P. in Engines.	°/₀ Useful Effect. Vol. Air measured at Surface.	Baro-meter.	Thermo-meter in External Atmos-phere.	Thermo-meter in Fan Drift.	Remarks.
In.			Lbs.		In.			In.			
2·75	6378	95·47	90	$\frac{1}{8}$	28	·154·7	61·7	30·65	44·5°	51·0°	
..	7425	146·26	87	$\frac{1}{4}$	28·25	229·57	63·71	30·6	43·5°	50·5°	
4·35	8292	207·15	90	$\frac{3}{8}$	28	322	64·3	30·6	43·0°	50·5°	
..	8896	271·8	88	$\frac{1}{2}$	28	402·4	67·54	30·6	43·5°	51·0°	

nd 8 feet diameter, supplying
nuary 1st, 1894.

Used Hour per Power in Mine.	Steam Consumed by Engine per Indicated Horse Power per Hour.	Fuel Consumption per Hour, per Indicated Horse Power in Engines.
Lbs.	Lbs.	Lbs.
·75	20·7	2·6

ND, SURREY.

and found to record as follows:—
99 per cent. of the true amount.
99 „ „ „

CHARLES CHREE,
SUPERINTENDENT.

sed was sent to be tested at Kew

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engines once in each hour, other observations being taken every half-hour. The results given are the average results yielded by an experiment extending over six hours.

The feed water passed through a Green's economiser before reaching the boilers.

The steam was generated by two Lancashire boilers, each 30 feet long by 8 feet diameter.

The fuel used was slack from the Wigan Nine-Feet and Wigan Four-Feet Mines.

In comparing the relative merits of the fan with the furnace as a ventilating appliance, the advantage is, without doubt, largely in favour of the fan. It is not uncommon for a furnace to consume 50 lbs. of coal or even more per horse-power per hour, in the air at the bottom of the upcast pit, whilst the tables annexed shew that by the employment of a fan the fuel consumption need not exceed 4·75 lbs. per horse-power per hour, in the air at the upcast pit bottom. In addition to this the fuel burnt at a ventilating furnace is usually of superior quality, and therefore of greater value than that burnt under steam boilers.

The ventilating power of a furnace is limited, and when that method of ventilation is employed, in addition to the danger of introducing fire into a mine which may give off large quantities of inflammable gas, and the risk of setting fire to adjacent coal or other strata, trouble constantly arises from the corrosive action of the products of combustion upon shaft fittings and tubbing, also from collapse of brick-work and leakage of tubbing owing to contraction and expansion due to the wide range of temperature in the shaft. This leakage has in some cases been so great as to reverse the air current by the cooling of the shaft, and the momentum of the falling water.

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The smoke and fumes are a source of great inconvenience where the shaft is used for winding coal, and this is especially the case where the shaft has to be utilised for the descent and ascent of workmen.

Mr. J. Unsworth proposed a hearty vote of thanks to Mr. Higson for his very valuable paper, in which he was very much interested. Perhaps it was only reasonable he should be, inasmuch as he had no practical knowledge of the working of fans and consequently he had listened to him with very great attention. He was quite sure he had made his points very clear, and had done his work well and was entitled to their thanks.

Mr. J. Dean, in seconding the vote of thanks said he had had to deal with a similiar fan at the Broomfield Pit and he could endorse everything Mr. Higson had said about the satisfactory working of it. It was a strong fan, economical, and certainly non-vibrating. He did not think they could hear it 30 yards from the place. He should like to ask Mr. Higson if he had had much experience with regard to the tightness of the rope gearing; they found that when the ropes were put on taut, according to the makers' wishes, they were very much troubled with them coming out of the grooves and getting broken. They had had two ropes broken. They had lengthened the ropes and given them from three to four feet of bag and they ran as steadily as possible.

The Chairman, congratulated Mr. Higson on his paper, and said: He had been a member of the Society a good many years and he did not remember hearing a paper from a mining point of view which he considered to be a better one. He thought it was more especially useful now that so many people had it on their minds to change their system of ventilation from furnace to fan, and those members who were

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thinking of doing so must be very grateful to Mr. Higson for his paper.

The motion was passed with applause.

Mr. Higson said he was very much obliged to them and as to Mr. Dean's question about the ropes, they had found exactly the same difficulty when the ropes were very tight they did not work satisfactorily. It was only when they had been running some time and had become slack that the jumping out of the grooves ceased.

Mr. Dean asked what was the size of the shaft the ventilation came up.

Mr. Higson: 14 feet 6 inches diameter.

Mr. Thos. Grundy asked Mr. Higson as to his experience in the thickness and construction of the walls of the fan chamber. They were putting down a large fan; and had noticed that the footing of walls, as given by the makers, had not proved sufficient, owing to the damp weather, he fancied, the water had acted upon it and the wall had given a little bit. When he mentioned it to the makers they suggested chipping the bricks off; but that did not suit his idea, because they had put the very best bricks in they could, to form the casing of the fan. If he was informed rightly, he believed considerable chipping had had to be done in connection with other fans. He would like to know what kind of bricks were used inside the chamber, and what were the means of carrying the rain or storm water from above the top casing of the fan.

Mr. C. M. Percy said he had no doubt in his own mind that furnace ventilation was a thing of the past and ought to be, and that fan ventilation was much more efficient; but the difficulty was in getting to know which was the best fan.

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They heard of such startling results—sometimes the efficiency claimed was more than 100 per cent.—that really practical men were bothered what to do; and whilst he was exceedingly glad that that paper, which was a very valuable one, had been read, he thought the discussion would more likely be of a searching character, and effect more good if it took place at a meeting after the paper had been printed and distributed. He joined in the congratulations to Mr. Higson. He might say that, at times, papers were not prepared with sufficient care. Papers ought to be prepared, first, to maintain the reputation of the person reading them, and, second, the reputation of the Society before which they were read. Looked at from these two points, Mr. Higson had set an excellent example, and had increased his own reputation and not lessened the reputation of the Manchester Geological Society.

The CHAIRMAN asked Mr. Higson to tell them what was the amount of coal in bulk used by the fan, and the amount of coal in bulk used by the furnace, when he made the comparison, assuming the two to be getting the same quantity of air. The Chairman went on to say that the question of fan and furnace was a very important one, both from a safety and also from an economical point of view. Where they had a fan they were able from the fact that they could manipulate it so easily to deal with dangers they could not overcome where they had a furnace. If they had a fire underground they could deal with the ventilation at once with a fan, but with a furnace they were perfectly helpless. With regard to the shaft, if they had a furnace it was difficult to examine it, and he imagined the ropes suffered very much, which must be a great drawback. If they had a fan they could examine the shaft and the ropes did not suffer in the same way. If Mr. Higson was correct in his statement as to the consumption of coal, there could be no

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question which system of ventilation was the most economical. During the last 10 or 15 years fans appeared to have made great headway, more especially in the northern districts, and in Lancashire they had made some steps in the right direction. They had a great many good fans, and he thought most of their large collieries were now thinking of changing from furnace to fan, but there were always a great many people whom it was difficult to get to make any improvement. There were two or three classes of colliery managers, and also of colliery owners. He found there was a class of colliery owner who seemed to love to see a huge black cloud of smoke coming up the pit. He did not know why it was, but he (Mr. Hall) thought he fancied it showed there was somebody below who was very busy. He often went to the extent of loving to see about his pits broken boxes, iron, and machinery, and he seemed to think it was a sign of energy on the part of his manager. It was a sign of energy in a certain direction. He loved to see the men and women employed on the pit bank exposed to a hurricane of rain and wind, and seemed to think it hardened them, and that it was a proper thing for colliery people to submit themselves to. As to the managers he personally tried to make the meeting at Wigan a good one. Whenever he met a colliery manager he asked him to come to the meeting. Some of them came, others looked at him with a kind of supercilious smile and passed on. He thought they were the losers and not those who attended. He was sure if any colliery manager in Lancashire had been there that afternoon he would have been interested in the paper which had been read. He did not know what steps one ought to take to get rid of that feeling of opposition to improvements. There was that feeling of opposition to improvements on the part of colliery managers and also of owners, but he did not quite see how they were to get over it. If one could hope

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to get them to join this Society, possibly it would be the right course, and before he sat down he should like to say a word about the support accorded to it. In the North of England nearly all the colliery owners subscribed to or became members of the Mining Institute, not possibly with the intention of attending the meetings, but simply to give it their support from a monetary point of view; whereas in Lancashire they had very few of the owners subscribing. He thought it would do great good if the owners would help the Society in that way, and although some of them might look down upon it—some of them he was sorry to say looked down upon that mining school and anything that was technical—but as far as he could judge their managers by attending these meetings would gain some knowledge which would eventually save the owners' pockets.

The motion was then put to the meeting and was heartily adopted.

Mr. Higson, in reply, said that with regard to the comparison of the results from the furnace and the fan, he might say they had not got a furnace at Messrs. Stone's collieries, but he had made inquiries and obtained the results he had quoted. Some were so startling that he was afraid to produce them. They had had no difficulty in the foundation of the fan race, and they used ordinary machine-cut brick.

Mr. Tonge said it was well known that the work of furnaces in mines varied proportionately with their depths; those at great depths giving far better results than those near the surface. In comparing the work of the fan with that of certain furnaces, Mr. Higson had not stated any depths, and so they could not form an accurate or definite judgment. However, he was not speaking at all in favour of the furnace; and he trusted when the time arrived for

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the paper to be discussed there would be a full meeting, as no more important subject could be discussed in connection with mining.

The discussion was then adjourned.

A vote of thanks to the Chairman closed the meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XXII. SESSION 1893-4.

MEETING AT OWENS COLLEGE.

An EXTRA MEETING of the Members was held, on the invitation of the Council, in the Geological Museum and the Beyer Buildings, Owens College, on the evening of Friday, 2nd February, 1894.

The Members assembled in the Geological Museum, where were on view the recent additions and the Kay-Shuttleworth Collection of Carboniferous Fossils, recently presented to the College by Sir Ughtred J. Kay-Shuttleworth, Bart., M.P.

Professor Boyd Dawkins also exhibited micro-sections of Coal in one of the Geological Laboratories.

Light refreshments were served in the Court Room to the Members and friends, after which an adjournment was made to the Natural History Lecture Theatre to hear Professor Dawkins' address.

The President: Mr. WILLIAM SAINT, H.M.I.M., in the Chair.

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ON THE SOUTH-EASTERN COALFIELD AT DOVER.

By Professor Boyd Dawkins, M.A., F.R.S.

CONTENTS.

1. *Introductory.*
2. *The Section of the South-Eastern Coalfield at Dover.*
3. *The Relation of the South-Eastern to other Coalfields.*
4. *The Rocks overlying the South-Eastern Coalfield.*
5. *The Cretaceous and Oolitic Formations.*
5a. *The Cretaceous Subdivisions.*
5b. *The Portlandian and Kimmeridgian Oolites.*
5c. *The Bed of Iron Stone.*
5d. *The Corallian Oolites.*
5e. *The Oxfordian and Callovian Oolites.*
5f. *The Bathonian Oolites.*
6. *The Thinning off of the Post-carboniferous Strata along a line to the West of Dover.*
7. *The Probable Depth at which the Coal Measures lie buried.*
8. *Conclusion.*

1. *Introduction.*

In the two papers read before the Geological Society in 1890 and 1892* the results of the boring carried out by Mr. Brady, under the direction of Sir Edward W. Watkin, and under my advice, were laid before the Society. In the first I pointed out the importance of the discovery of the Coal Measures under the Secondary rocks, at a depth of 1,113 feet below high watermark, in the boring at Shakespeare Cliff, well within the limit of workable distance from the surface. In the second the results of boring to a greater depth were treated. It was shown that the Coal Measures were proved to extend to a depth of

**Trans. Manch. Geol. Soc.*, xx., 11th March, 1890, xxi., 29th January, 1892, p. 456. For the history of the discovery see also *Proceed. Royal Institution*, 6th June, 1890, and the *Contemporary Review*, April, 1890.

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1,875 feet below H.W.M., to possess a thickness of 762 feet, and to include nine seams of coal with a total thickness of 17 feet 8 inches, and with a workable thickness of 14 feet. The hope then expressed that new seams of coal would be met with at greater depths has been fully verified by the continuation of the borehole. The Coal Measures have now been proved to a depth of 2,181 feet 6 inches below high water mark, with a four-foot seam of bituminous coal at the bottom. In this communication I propose to give details of the boring, and to work into the section privately printed by Mr. Brady the results of the examination of the cores made by myself and others who have been consulted on the boring.* I shall first of all treat of the Coalfield, and then pass on to the examination of the overlying rocks.

2. *The Section of the South-Eastern Coalfield at Dover.*

The results of the boring into the Coal Measures are presented in the following section :—

DETAILS OF COAL MEASURES IN BORING AT SHAKESPEARE CLIFF.

	Depth below H.W.M. ft.	in.	Thickness. ft.	in.	Remarks.
Carboniferous, dark shale ..	1113	0	11	6	
Sandstone	1124	6	1	0	
Blue Bind	1125	6	11	0	Calamites.
1. Coal Seam, bright and bituminous, with sandstone parting	1136	6	3	6	Good house Coal 2ft. 6in.
Clay, with black carbonaceous lines	1140	0	7	6	

* Dover Coal Boring. Observations on the Correlation of the Franco-Belgian, Dover, and Somerset Coalfields, by Francis Brady, C.E., June, 1892, with Reports by M. Victor Watteyne, Mons; James Mc.Murtrie, F.G.S., Radstock; and M. R. Zeiller, Paris; Zeiller *Compt. Rend.*, 24th October, 1892, *Sur les Empreintes du Sondage de Douvres.* See also Bertrand, *Trans. Federated Inst. of Mining Engineers, 2nd June, 1893: The Correlation of the Coalfields of Northern France and Southern England.*

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	Depth below H.W.M. ft.	in.	Thickness. ft.	in.	Remarks.
Sandstone, with black carbonaceous lines	1147	6	3	6	
Shale, with coal parting ..	1151	0	6	6	
Sandstone, with black carbonaceous lines	1157	6	42	6	
2. Coal Seam	1200	0	0	6	
Sandstone	1200	6	28	0	
3. Coal, good, blazing, with specks of iron pyrites ..	1229	0	2	0	Cleat, in slightly deformed cubes.
Under Clay	1231	0	1	6	
Shale	1232	6	16	0	
Blue Bind	1248	6	30	6	
4. Coal, blazing, with specks of iron pyrites..	1279	0	2	0	Cleat, as above.
Blue Bind	1281	0	19	0	
Sandstone	1300	0	11	9	
5. Coal, bituminous	1311	9	1	3	Cleat, as above.
Shale	1313	0	1	6	
Dark grey, hard Bind	1314	6	47	0	
Sandstone	1361	6	46	0	
Dark grey Bind, with thin Sandstone bands	1366	0	38	0	
Blue Bind	1404	0	12	0	
Dark grey Bind..	1416	0	11	0	
Fire Clay, with traces of Coal	1427	0	1	0	
Hard Fire Clay..	1428	0	5	0	
6. Coal Seam	1433	0	1	0	
Dark grey Sandstone, with carbonaceous streaks	1434	0	7	0	
Dark laminated Bind	1441	0	15	0	
7. Coal	1456	0	2	6	Good house Coal.
Fire Clay and Bend	1458	6	8	6	
Hard dark Bind	1467	0	5	0	
Dark grey Sandstone, with carbonaceous lines	1472	0	41	0	
Laminated Bind	1513	0	2	0	
Sandstone, with carbonaceous lines	1515	0	16	0	
Dark grey Sandstone, with carbonaceous lines	1531	0	18	0	
Coal Seam, thin	1548	10 (?)	0	2 (?)	
Dark grey Bind..	1549	0	2	6	
Sandstone	1551	6	3	6	
Bind	1555	0	4	0	
Dark grey Bind	1559	0	11	0	

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		Depth below H.W.M. ft.	in.	Thickness. ft.	in.	Remarks.
8.	Coal, clean bright	1570	0	2	3	Coking Coal.
	Bind	1572	8	4	9	
	Hard grey Sandstone, with carbonaceous streaks ..	1577	0	30	0	
	Bind	1607	0	2	0	
	Hard grey Sandstone, with carbonaceous partings....	1609	0	64	0	
	Coarse grey grit, with traces of Coal..	1673	0	8	0	
	Hard grey Sandstone, jointed with carbonaceous partings	1681	0	48	0	
	Hard dark grey Bind	1729	0	10	6	Volatile Compounds 22
	Hard grey Sandstone, jointed with carbonaceous partings	1739	6	24	3	Carbon .. .. .. 68 Ashes 10
9.	Coal, clean bright..	1763	9	2	9	Carbon .. .. 83·80
	Dark compact Under Clay ..	1766	6	5	6	Hydrogen .. 4·79 Oxygen.. .. 4·15
	Fine grained grey Sandstone, jointed	1772	0	11	0	Heating power, 14,867 units.
	Dark grey Bind, with Clay partings	1783	0	12	0	
	Sandstone and Bind..	1795	0	4	0	
	Fine grey laminated Sandstones and Shales, with traces of Coal	1799	0	32	0	
10.	Coal, clean bright	1831	0	1	8	Cleat, as above.
	Hard Under Clay..	1832	8	3	4	
	Fine grained dark grey Sandstone	1836	0	5	0	
	Dark grey Bind, jointed ..	1841	0	10	0	
	Dark grey Clay, soft	1851	0	2	0	
	Shale, Bind and Clay	1853	0	2	0	
	Laminated Bind	1855	0	3	0	
	Compact dark Bind	1858	0	2	0	
	Dark grey Sandstone, with traces of Coal and Plants..	1860	0	7	0	
	Hard grey Sandstone	1867	0	5	0	
	Hard grey Sandstone, with traces of Coal	1872	0	14	0	
	Hard grey Sandstone, with Plants..	1886	0	9	0	*Mariopteris. Neuropteris Scheuchzeri*, Hoffm. *N. rarinervis*, Bunb. *N. tenuifolia*, Schloth. *Lepidodendron aculeatum*, Sternb. *Carpolithes coreulum*, Sternb.

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		Depth below H.W.M. ft.	in.	Thickness. ft.	in.	Remarks.
	Grey Sandstone, with traces of Coal	1895	0 ..	30	0	*Cyclopteris. Neuropteris Scheuchzeri. N. rarinervis. N. tenuifolia. Calamophyllites Goepperti*, Ettingsh. *Lepidostrobus variabilis*, Lind and Hutt. *Cardiocarpus* (*Carpolithes corculum*, Sternb.)
	Sandy Bind	1925	0 ..	3	0	
	Hard grey Sandstone, with traces of Coal	1928	0 ..	55	0	
	Dark grey Bind, with Plants	1983	0 ..	3	0	
	Hard dark grey Clay, with Plants	1986	0 ..	14	0	
	Dark grey jointed Sandstone	2000	0 ..	5	0	
	Dark grey sandy Bind	2005	0 ..	4	0	
	Hard dark Fire Clay	2009	0 ..	4	0	
	Sandy Bind	2013	0 ..	1	0	
	Fine grey Sandstone	2014	0 ..	2	0	
	Dark grey Bind, with Plants	2916	0 ..	22	0	*Neuropteris Scheuchezeri.* (?) *Lepidodendron lycopodioides*, Sternb. *Stigmaria ficoides*, Sternb.
11.	Hard Coal	2038	0 ..	1	0	
	Hard dark grey Fire Clay ..	2039	0 ..	8	0	
	Dark Shale, with Plants and Coal partings..	2047	0 ..	3	0	
	Clay Bind, with Plants ..	2050	0 ..	4	0	
	Sandy Bind	2054	0 ..	4	0	
	Coarse grey Sandstone, with traces of Coal	2058	0 ..	27	0	
	Grey bedded grit, with carbonaceous partings	2085	0 ..	20	0	
	Hard grey Sandstone, with Coal partings	2105	0 ..	14	0	
	Blue Bind	2119	0 ..	5	0	
	Sandy Bind	2124	0 ..	2	0	
	Blue Bind	2126	0 ..	2	0	
	Fine grained Sandstone ..	2128	0 ..	7	0	
	Sandy Bind	2135	0 ..	9	0	
	Dark Shale, with Coal partings and Plants..	2144	0 ..	3	0	
	Dark grey broken Bind	2147	0 ..	5	0	

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	Depth below H.W.M. ft.	in.	Thickness. ft.	in.	Remarks.
Blue Bind	2152	0	3	0	
Fine grey jointed Sandstone.	2155	0	3	0	
Dark grey Clay Bind	2158	0	3	0	
Fine grey Sandstone, with 5in. layer of blue Bind ..	2161	0	5	0	
Dark grey Bind..	2166	0	11	6	
12. Bituminous Coal	2177	6	4	0	

The boring in December, 1892, was carried down to 2,181 ft. 6 in. below H.W.M., or 2,225 ft. 6 in. below the surface, and the first or experimental stage of the discovery was completed by the proof of the existence of a four-foot seam of good blazing coal at the bottom, which puts an end to any doubt as to the commercial value of the coalfield. "When the many seams in the French, Belgian, and Westphalian fields are taken into account, the discovery of more seams at Dover is, in my opinion, merely a question of sinking deeper. I should also expect to meet with thicker seams, as in the Département du Nord, where they run to a thickness of four feet." This extract from one of my reports printed in the Proceedings of the General Meeting of the South-Eastern Railway Company, 23rd July, 1891, and relating only to the coal seams down to 1,500 feet, has thus been completely verified by the later discoveries at greater depths. It applies equally to the present position of the work. The existence of 12 seams of coal, great and small, amounting to a total thickness of 23 ft. 5 in. has been proved. We cannot tell how many more seams await discovery in the unknown region below.

3. *The Relation of the South-Eastern Coalfield with other Fields.*

The correlation of the South-Eastern coalfield with those of Somerset and South Wales on the West, and North France and Belgium on the East, has already been placed before

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the Society in my previous papers, as well as its position exactly in the line between the two points where Godwin Austin, in 1859, and Prestwich, at a later date, believed it to exist. It is important to fix, if possible, its exact horizon in these well-known fields. According to Mr. McMurtrie, it belongs to the upper division of the Somerset coalfield and is represented by the Radstock and Farrington measures overlying the massive grits—the Pennant rock—which divide the upper from the lower Coal measures in the Somerset and South Welsh fields. In the opinion of M. Watteyne, the Chief Engineer of Mines in Belgium, they are to be grouped with the bituminous middle coals of the Belgian fields, which are at the same horizon as the above fields in Somerset. M. Zeiller concludes from the examination of the plants that it belongs to the upper region of the middle coals, and is not older than the "fat" coals of the Pas de Calais. We may therefore conclude that the horizon of the South-Eastern coalfield is that of the valuable upper measures of Somersetshire, and of the important middle Coal measures of Belgium and Northern France. It must however be noted that the gentle dip of the strata of 2° only from the horizontal is quite exceptional in the above mentioned fields. This may perhaps be explained by the view placed before the Society in 1892, that the boring traverses the centre of an east and west trough.

4. *The Rocks overlying the South-Eastern Field.*

A glance at a geological map shows that the exposed coalfields of England lie buried under a thick mantle of Secondary strata on their Eastern margins along a line extending from the Staffordshire fields through Nottingham and the district of Retford. In Somersetshire too, and in Gloucestershire, the Secondary strata conceal the edges of the coalfields. In many places, away from the exposed area, the coals are worked underneath the Secondary rocks.

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In Belgium and Northern France, the coalfields are as a rule worked under the Secondary rocks. It is therefore of practical importance to ascertain the various subdivisions of the overlying rocks at the Shakespeare Cliff, and to compare them with those in other places in South-Eastern England, where deep borings have been made.

The following is the section :—

DETAILS OF THE STRATA OVERLYING THE SOUTH-EASTERN COALFIELD AT SHAKESPEARE CLIFF.

	Depth below H.W.M. Feet.	Thickness. Feet.	Remarks.
Upper Cretaceous—			
Lower Grey Chalk	H.W.M...	91	
Chalk Marl	91 ..	39	
Glauconitic Marl	130 ..	8	
Gault	138 ..	118	
Sandy Gault	256 ..	3	
Lower Cretaceous, or Neocomian—			
Quartzose Sandstone, with green grains..	259 ..	5	
Cherty Limestone..	264 ..	2	
Dark Green and Black Sand.	266 ..	20	
Bluish grey Clay	286 ..	17	
Fine Greensand..	303 ..	4	
Black Sandy Clay	307 ..	14	
White Sandstone	321 ..	2	
Dark grey laminated Grey Sandy Marl	323 ..	37 ..	With septarians of clay ironstone and vegetable impression.
Stiff brown Clay	360 ..	19	
Fine white Marl	379 ..	1	
Dark grey Marl	380 ..	13	
Black Shale	393 ..	7 ..	Ganoid scales.
Fine laminated grey Marl ..	400 ..	6	
Calcareous Grit, with glauconite grains	406 ..	3	
Marly Clay..	409 ..	18	
Earthy Ferruginous Limestone	427 ..	2 ..	Serpula.
Calcareous Sandstone	429 ..	1	
Shale, black sandy	430 ..	14 ..	Fossil wood.
Limestone	444 ..	1	
Grey Marl	445 ..	5	

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	Depth below H.W.M. Feet.	Thickness. Feet.	Remarks.
Limestone	450 ..	2	
Quartz conglomerate with sandy matrix..	452 ..	1 ..	Vein quartz pebbles, about size of beans.
Grey Marl	453 ..	4	
Limestone	457 ..	5	
Sandy Marl	462 ..	6 ..	Vein quartz pebbles.
Dark grey Clay..	468 ..	5	
Grey Limestone	473 ..	8 ..	With broken shells.
Dark Marl, green sandy....	481 ..	4	
Grey Limestone	485 ..	2 ..	With broken shells and fragments of Pinna.
Grey Marly Clay	487 ..	7 ..	Full of grains of glauconite.
Grey Sandstone	494 ..	3	
Marl	497 ..	3	
Grey earthy Limestone ..	500 ..	4 ..	? Nodule in Marl.
Grey Marl..	504 ..	1	
Oolitic Strata—			
Calcareous grit	505 ..	3	
Grey Marlstone..	508 ..	4	
Grey Oolitic Limestone ..	512 ..	7 ..	Rhynconella.
Grey Marlstone..	519 ..	1	
Oolitic Limestone, grey	520 ..	7	
Grey Calcareous Sandstone	527 ..	8	
Compact Sandstone	535 ..	2 ..	Exogyra.
Grey Marl, with pebbles of vein quartz..	537 ..	2 ..	With millet seed-like nests of ferric oxide.
ard grey Limestone	539 ..	1	
Brown Calcareous Sandstone ..	540 ..	2	
Grey shelly Limestone	542 ..	1 ..	Oolitic grains of ferric oxide.
Dark grey Marl	543 ..	2	
Hard blue Limestone	545 ..	1 ..	Littorina.
Millet seed or Brown Oolitic Ironstone*	546 ..	12 ..	Oolitic grains of ferric oxide. *Ostræa deltoidea?*
Grey Limestone	558 ..	4	
Dark bituminous Clay	562 ..	8	
Flaggy Sandstone..	570 ..	2	
Grey sandy Clay	572 ..	4	
Arenaceous Limestone..	576 ..	7 ..	Cidaris.
Dark bituminous Shale	583 ..	27	

*In Mr. Brady's section this is described as "Brown rubbly sandstone, full of brown polished millet seed grains."

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	Depth below H.W.M. Feet.	Thickness. Feet.	Remarks.
Grey nodular Limestone	610 ..	2	
Coralline Oolite..	612 ..	42 ..	*Pecten vagans*, Sow. *P. Vimineus*, Sow. *Cidaris florigemma*, Phil. *Hemicidaris*, *Terebratula intermedia*, Sow. *Thamnastræa*, *Thecosmilia*.
Clayey Limestone..	654 ..	3 ..	Astarte, Cidaris.
Compact grey Limestone..	657 ..	6	
Sandstone	663 ..	2	
Grey Limestone	665 ..	1	
Brown Sandstone..	666 ..	1	
Grey Limestone, hard and pure..	667 ..	5	
Nodular Sandstone	672 ..	1	
Limestone	673 ..	7	
Arenaceous Limestone..	680 ..	4	
Nodular Sandstone	684 ..	1	
Grey muddy Limestone	685 ..	4 ..	*Cidaris florigemma*, Phil. Hemicidaris, Plicatula.
Sandy Marl	689 ..	1	
Grey muddy Limestone	690 ..	15 ..	Astarte. *Trigonia clavellata*, Park. Lima. Exogyra. *Terebratula intermedia*, Sow.
Sandy Marl	705 ..	1	
Grey muddy Limestone	706 ..	33 ..	Terebratula. Plicatula. *Ostræa gregaria*, Sow. *Lithodomus inclusus*, Phil.
Marly clay..	739 ..	7	
Shelly Limestone..	746 ..	3	
Sandy Clay	749 ..	2	
Hard Limestone	751 ..	1	
Sandy Clay	752 ..	3	
Hard blue Limestone	755 ..	1	
Sandy Clay	756 ..	3	
Grey Arenaceous Limestone ..	759 ..	10	
Dark Sandy Clay	769 ..	6	
Sandstone	775 ..	2	
Black Marl..	777 ..	2	
Sandstone	779 ..	1	
Marl	780 ..	5 ..	*Ostræa gregaria*, Sow.
Shelly Sandstone	785 ..	1 ..	*Rhynconella spathica*, Lam. *Ostræa gregaria*, Sow. *Mytilus imbricatus*, Sow.
Brown Sandy Marl	786 ..	6	
Calcareous Sandstone	792 ..	3	

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	Depth below H.W.M. Feet.	Thickness. Feet.	Remarks.
Shale	795 ..	43	
Marly Limestone	838 ..	1	
Shale	839 ..	7	
Shelly Limestone	846 ..	2	
Dark grey Marl..	848 ..	34	
Marly Limestone	882 ..	1	
Brown Sandy Clay	883 ..	22 ..	*Gryphæa dilatata*, Sow.
Calcareous Sand	905 ..	2	
Sandstone	907 ..	3	
Brown Sandy Clay	910 ..	1 ..	Belemnites. *Rhynconella socialis*, Dav.
Brown Sandstone	911 ..	4 ..	Ganoid scales; quartz pebbles of size of bean; Belemnites, broken, and possibly derived.
Calcareous Sand	915 ..	3	
Hard grey Limestone	918 ..	3	
Calcareous Sand	921 ..	1 ..	Iron pyrites, grains of quartz, and glauconite.
Brown Sandstone	922 ..	4 ..	Lignite and shells.
Calcareous Sand	926 ..	3	
Sandstone	929 ..	2	
Clay..	931 ..	4 ..	Vegetable impressions; Bivalve shells.
Calcareous Sand	935 ..	3 ..	Gryphæa.
Dark grey Marl	938 ..	2	
Bluish grey Clay	940 ..	12	
Brown Sand	952 ..	1	
Hard grey Marl..	953 ..	4	
Shelly Limestone	957 ..	2	
Grey Marl	959 ..	4	
Siliceous Limestone	963 ..	3	
Sandstone	966 ..	1	
Marl	967 ..	1	
Shelly Limestone	968 ..	1	
Dark Marl	969 ..	5	
Earthy Limestone	974 ..	1	
Marl..	975 ..	2	
Sandstone	977 ..	1	
Oolitic Limestone..	978 ..	8 ..	*Terebratula globata*, Sow.? *Ostræa Sowerbyi*, M. L. Gryphæa, Belemnites.
Sandstone	986 ..	1	
White shelly Oolitic Limestone.	987 ..	9 ..	Gryphæa, Belemnites.
Marl	996 ..	2	

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	Depth below H.W.M. Feet.	Thickness. Feet.	Remarks.
White shelly Oolitic Limestone.	998	15	*Ostræa Sowerbyi*, M. L. *Rhynconella varians*, Schlot.
Calcareous Sand	1013	5	
Hard grey Limestone	1018	14	*Clypeus Plotii*, Klein. Chemnitzia, Serpula, Gryphæa, *Rhynconella concinna*, Sow.
Sand	1032	1	
Hard Limestone	1033	3	
Calcareous Sand	1036	1	
Dark grey Limestone	1037	10	
Calcareous Sand	1047	1	
Dark grey Marl	1048	5	
Calcareous Grit	1053	3	
Bedded Sandstone	1056	3	
Calcareous Grit	1059	4	
Dark grey Sand	1063	13	
Hard grey Clay	1076	7	
Hard dark grey Limestone	1083	2	
Dark grey Marl	1085	1	
Grey argillaceous Limestone	1086	3	
Marl	1089	1	
Hard grey Limestone	1090	1	
Marl	1091	1	
Hard grey Limestone	1092	1	
Marl	1093	1	
Hard grey Limestone	1094	2	
Dark grey Clay	1096	5	
Earthy Limestone	1101	1	
Dark grey Clay	1102	6	
Limestone	1108	1	
Marl	1109	1	
Limestone	1110	1	
Marl	1111	1	
Sandstone	1112	1	
Coal Measure Shale	1113	11·5	

5. *The Cretaceous and Oolitic Formations.*

The strata in the above section belong to the following formations :—

	Depth below H.W.M. Feet.	Thickness. Feet.
Upper Cretaceous = 259 feet—		
Lower Grey Chalk and Chalk Marl	H.W.M.	130
Glauconitic Marl	130	8
Gault	138	121

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	Depth below H.W.M. Feet.	Thickness. Feet.
Lower Cretaceous, Neocomian, or Lower Green Sand = 246 feet		
Folkestone Beds..	259	64
Sandgate Beds..	323	77
Hythe Beds..	400	87
Atherfield Clay	487	18
Oolitic = 608—		
Portlandian Oolites	505	32
Kimmeridgian..	537	73
Corallian	610	159
Oxfordian, Callovian	769	188
Bathonian	957	156
Coal Measures..	1113	1068·5

In dealing with the Oolitic rocks I have been mainly led by the fossils from the boring, and by the examination, under the guidance of M. Rigaux, of the rocks overlying the Coal Measures in the Boulonnais, where the strata traversed in the boring can be studied at leisure in the cuttings and quarries open to the light of day.* I have also had the advantage of studying the Oolitic rocks of Somerset and Wilts along with the Rev. H. H. Winwood.

5A. *The Cretaceous Subdivisions.*

The Cretaceous strata demand no special notice, because they can be studied in the cliffs between Hythe and Dover, and have been fully described by Fitton† and Topley.‡

5B. *The Portlandian and Kimmeridgian Strata.*

The Infra-neocomian strata of thin limestones, marls, and sandstones, ranging from 505 to 610 feet below high water mark, can only be provisionally grouped by the scant

* I am greatly indebted to M. Rigaux for accurate information as to the geology of the Boulonnais. Our party consisted of Mr. Mark Stirrup, Mr. Topley, and myself.

† Fitton, *Geol. Trans., Lond., Sec. 2., Vol. IV., p. 103 et seq. Proceed. Geol. Soc., Lond., I., p. 6 ; and IV., p. 198.*

‡ Topley, *Geology of Weald, Geological Survey Memoir. 1875.*

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evidence offered by the physical characters and the few fossils which are mostly too fragmentary for specific identification. They are, however, all marine. The calcareous sandstones, marls, and oolitic limestones (at 512 ft. and 520 ft.,) with Exogyra and Rhynconella are probably to be referred to the Portlandian series. The oolitic limestones in particular are of the same type and occupy the same position in the series as the Portland Stone of the Vale of Wardour, and of Bourton in Berkshire.* They also agree with the oolite described by M. Rigaux as occurring at the same horizon at Terlincthum in the Boulonnais.† The Portland sand may perhaps be represented by the sandstones with Exogyra which come in at 527 below H.W.M., and range down to 537 feet.

From this point down to 610 feet the strata are probably of Kimmeridgian age, and present the same general faces as the deposits between the Corallian and the Portlandian Zones in the Boulonnais.

5c. *The Iron Stone.*

The bed of iron stone 12 feet in thickness which comes in at a depth of 546 feet presents very singular physical characters. It is composed of small dark brown shining grains of hydrated oxide of iron, like millet seed, imbedded in a base partly composed of calcium carbonate and partly of iron carbonate. These grains are oolitic in structure, and are probably the result of the same series of chemical changes by which the calcareous beds of the inferior oolite have been converted in Lincolnshire into the ferric oxide of the iron ores. This singular stratum of iron ore so closely resembles the Millet seed granular iron ore described

* Godwin-Austen, *Quart. Journ. Geol. Soc., Lond., VI., p. 462;* Blake, op. cit. XXXVI, p. 199.

† Notice *Géologique sur le Bas Boulonnais*, 8vo., Boulogne, 1892, p. 84.

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by Blake and Hudleston,* at Abbotsbury, in Dorset, which occurs also above the Corallian oolite, that there is every reason to group them together in the same horizon.† At Abbotsbury it is a purely local deposit with its relation to the rocks above and below not clearly defined, but clearly intercalated between the Coralline oolite below and the main mass of the Kimmeridgian above.

It is also physically identical with the valuable iron ore worked for many years at Westbury, in Wiltshire, and which presents the following section :—

		Ft.	In.
6	Kimmeridge Clay, with *Ostræa deltoeides*	10	0+
5	Dark Brown Oolitic Ironstone	7	0
4	Band of *Ostræa deltoeidea*	1	0
3	Oolitic Ironstone, mottled dark grey	8	0
2	Ferruginous Marls and Sands	4	0
1	Corallian Oolitic limestones	20	0

The range of *Ostræa deltoeidea* down from the Kimmeridge clay to the top of the Corallian limestones is, in my opinion, proof that this ironstone series is of Kimmeridgian age. It is, however, considered by Blake and Hudleston to be Corallian.

In the section at Dover it is mapped off from the Corallian by 52 feet of rock mostly clay and bituminous shale, probably Kimmeridgian. I should, therefore, group it with the latter, rather than follow the above authors in treating it as of Corallian age.

This bed of ironstone will probably turn out to be of great commercial value, because it can be worked in connection with the coal seams below. Its discovery is, in my opinion, only second in importance to that of the South-Eastern Coalfield.

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* *Quart. Journ. Geol. Soc., XXXIII., p. 273.*

† Mr. Hudleston, whom I have consulted on this point, also concurs in this view.

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5D. *The Corallian Oolites.*

The Ceralline oolite, at a depth of 610 feet and 42 feet in thickness, and with the usual fossils commonly occurring in it both in England and France, presents a marked and clearly defined horizon. The beds below also are proved by their fossils to belong to the Corallian Zone, as far down as 706 feet, and with them I should group the limestones and shales as far down as 769 feet. This would make the Corallian series 159 feet in thickness.

5E. *The Oxfordian and Callovian Oolites.*

The dark marls, clays, sandstones, and thin layers of limestone, ranging from 769 to 957 feet, represent the Oxfordian and Callovian group of rocks, with *Gryphœa dilatata, Rhynconella spathica, Ostræa gregaria,* and *Mytilus imbricatus,* and are 188 feet in thickness.

5F. *The Bathonian Oolites.*

The thin limestones come in again below at a depth of 957 feet, and as we descend to the horizon of the Great Oolite, grow thicker and occur in beds as much as 15 feet in thickness. They contain *Ostræa Sowerbyi, Rhynconella varians, R. concinna,* and *Clypeus Plotii,* and clearly belong to the Bathonian group of Southern England and of the Boulonnais down to 1,018 feet. Below this they pass down into the thin limestones, clays, and sands which cover the Coal Measures. These latter, in all probability, belong to the division of Inferior oolite, and are of the same type as those resting on the Coal Measures and Devonian rocks, at Marquise, in the Boulonnais.

6. *The thinning off of the Post-carboniferous Rocks along a line to the West of Dover.*

The Permian, Triassic, and Liassic rocks are conspicuous by their absence in the above section, as in the coalfields of

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the Boulonnais, and the Oolites of the Bathonian or lowest sub-division rest directly as the coal-bearing strata.

The Wealden fresh-water deposits, too, which appear under the Atherfield clay to the South of Hythe, and occupy so large an area in Kent and Sussex, and are no less than 1,400 feet thick, have left no distinctive mark in the section, and if present are so thin as to have escaped observation. In the short distance of about nine miles (from Hythe to Dover) they have thinned off northwards, against Godwin Austin's barrier of carboniferous and pre-carboniferous rocks, which constitute the axis of Artois.

The Oolitic rocks also show signs of a diminution in thickness. In the boring at Netherfield, near Battle, in Sussex, which began in the Lower Wealden strata, the Oolites, as far down as 60 feet into the Oxford clay, were no less than 1,705 feet thick, as compared with a total thickness of the Oolites at Dover of 608 feet. In the area of London they are 87·5 feet at Richmond, and 64 feet at Meux's Brewery, in the Tottenham Court Road, and they are altogether absent from the other deep borings in the district.

It is obvious, therefore, that the Oolites are thinning off from Battle and Hastings northwards towards London, and that the area of the North Downs, where the Wealden and Oolitic rocks thin off against the barrier, offers a favourable place for further trials. Along this east and west line borings might be put down so as to avoid the chalk which is not less than about 800 feet thick.

In my opinion, along this line, the South-Eastern Coal Measures will be proved to be continued to the west, and at no very great depth from the surface.

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7. *The Probable Depth at which the Coal Measures lie buried.*

On this point the deep sinkings and borings in Southern England and North-Eastern France throw a flood of light. From the examination of the following (*page 506*) table it is clear that the carboniferous and pre-carboniferous rocks occur at depths not greater than 1,200 feet below H.W.M. The Coal Measures may, therefore, be expected to occur to the west of Dover at about that depth, while further to the south they are buried beneath much greater thicknesses of rock, amounting at Battle to more than 1,900 feet.

8. *Conclusion.*

In conclusion, it remains to say that the experimental boring at Dover promises to open out a new field for scientific exploration, and is likely, ultimately, to have a profound affect on the railways and general industries of South-Eastern England. Begun in 1886, the Coal Measures were not struck until 1890, and the proving of the seams down to a depth of 2,181 feet below H.W.M. was completed in December, 1892. The discovery of the ironstone in the Oolites is also of great importance.

The experimental stage is over. It now remains to develop the South-Eastern Coalfield to the advantage of the industries of the district. If it be objected that this will destroy the rural beauty of the district, consolation may be found in the thought that after all the effect will be to turn the Cliffs of Dover into studies in black and white. They will make an admirable background for a picture of the economic revolution, which undoubtedly will result from the discovery of vast mineral wealth in South-Eastern England.

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TABLE OF DEEP BORINGS IN SOUTHERN ENGLAND AND NORTH-EASTERN FRANCE.

	Burford.	Harwich.	Ware.	Turnford.	Loughton.	Kentish Town.	Tottenham Court Road.	Crossness Boring.	Richmond Well.	Chatham Boring.	Calais.	Hames Bucres.	Battle.	Dover.
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Alluvium	..	35	14	20	..	..	22	39	10	15	85·5	6	..	..
London Clay	..	23	..	..	167	236	63	..	180	..	..	..	..	..
Woolwich Beds and Thanet Sand	..	28	..	50	76	88·5	72·5	97·5	82	12	161	..	..	..
Chalk	..	888	601	730	648·5	645	655·5	637·5	670	682	765	630	..	130
Glauconitic Marl	..	22	20	20	37	13·5	28	65	10	..	3	1	..	8
Gault	..	39	160	161	132·5	130·5	160	176	201·5	193	25	32·5	..	121
Lower Greensand	..	..	..	..	31·5	..	..	..	10	41	65	..	..	246
Wealden (Purbeck)	..	..	..	..	..	..	..	..	.	..	..	..	200	..
Portlandian	..	..	..	..	..	..	..	..	..		..	..	52	32
Kimmeridgian	.	..	..	..	..	..	..	..	..		..	..	*1517	73
Corallian	..	..	..	..	..	..	..	..	..	22	..	..	76	159
Oxfordian	..	..	..	..	..	..	..	..	..		..	..	60	188
Callovian	198	.	..	..	..	..	..	..	..		..	..	..	
Bathonian	..	..	..	..	..	..	64	..	87·5	..	..	..	..	156
Liassic	598	..	..	..	..	..	..	..	..	..	..	..	..	..
Rhœtic	10	..	..	..	..	..	..	..	..	..	..	..	..	..
Triassic	428	..	..	..	..	..	..	..	..	..	..	..	..	..
Carboniferous	225	44·5	..	..	..	..	..	..	..	..	34	..	..	1068
Devonian	..	..	..	30	..	188·5	80	60	208	..	..	6	..	..
Silurian	..	..	43	..	..	..	..	..	..	..	..	..	..	..
Total depth	1400	1070	839	1071	1090·5	1302	1145	1075	1447	965	1104	675	1905	2225

* Dixon, *Geology of Sussex, &c., Brighton, 1878.* Topley, *on the History of the Subwealden Boring, near Battle, p. 151 et seq.* For the thickness of the Kimmeridge Clay and the Corallian rocks I have taken Topley's figures. Hudleston, however, is inclined to group them as respectively 1078 and 515 feet.

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Mr. G. C. Greenwell, F.G.S., said: I am sure all present will agree with me that the best thanks of this meeting should be given to Professor Boyd Dawkins for his most interesting address. I am sure no one would be less satisfied than the Professor himself if there were not some little differences of opinion upon certain points. I have seen the boring, and I have seen samples of coal that have come out of the boring, and from these I draw a conclusion of my own, which happens not to tally exactly with the conclusions of Professor Boyd Dawkins. I know the Somerset coalfield well. I have seen, and known, coal in the neighbourhood of Mons; I have seen coal in the neighbourhood of Liège; and I have seen the borings represented in these sections of Professor Boyd Dawkins. Comparing what I have seen in Somersetshire—that is, what Professor Boyd Dawkins has described to you as being the upper series of bituminous coal there, and the lower coal, which he states is not so bituminous—I beg, with very great deference, to express a somewhat varied opinion. The coal in the upper series in Somersetshire is undoubtedly bituminous. It is suitable for making gas, and it will also coke; but it is not so fine a description of coal as the coal that is worked at Mons, nor so fine as that worked near Liège. It is not so bright as the lower coals of Somersetshire. From a careful examination I have come to the conclusion that the coal which has been found at Dover corresponds, not with the upper coal, but with the lower coal. Of course these are mere matters of opinion at the present time; and, in the words of the old proverb, those who live longest will see the most. I do not think it necessary to make any further remark upon that. As to the inclination of the seams mentioned by Professor Boyd Dawkins, I prefer not to give an opinion. Many of you may have had opportunities of examining the cores in the South Kensington Museum taken

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from this Dover borehole. There is one core taken from a bed of shale. I speak under correction; but I think that the plane of lying, so to speak, of a fossil plant will indicate what, at the time when that plant was laid there, would be a level surface. Now, if you will examine the particular core I am speaking of, you will find that the plane in which these plants lie is not a plane indicating horizontal strata; the bed is inclined at an angle of something like 45 degrees. The fact of a core being brought up with a flat bottom to it, and the fact of its showing striæ, so to speak, is hardly, to my mind, sufficient proof of horizontality of strata. I am sure you will cordially endorse the proposal which I now make, that the best thanks of the Society be given to Professor Boyd Dawkins for his most able exposition.

Mr. Joseph Dickinson said: I have much pleasure in seconding the vote of thanks to Professor Boyd Dawkins for the very interesting description which he has given us of the explorations at Dover. It is always a treat to hear Professor Dawkins. He has so interesting a way that one really imbibes the knowledge without any difficulty whatever. The views Mr. Greenwell has expressed are entitled to consideration, from his experience in practical boring. At the same time I am disposed to think the Professor's view as to the dip will be nearly correct; for, although the diamond drill, in going through, may, perhaps, tend to fracture these cores off a little more horizontally than they really are, yet there is in the bedding of the coal such a form of crystallisation that a practised eye can tell whether it is broken across the grain or with the grain. I do not know that I can add anything to what both gentlemen have said. When the indication was given of the probability of coal being found at Dover, which is now ascribed to Mr. Godwin Austin, I could not help thinking that due credit should have been given to another geologist, Professor

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Prestwich, for the part he took in laying down this probable line of coalfield. It may be that when two people ride on the same horse one has to sit behind. Professor Prestwich was not so prominent a member as Mr. Godwin Austin, but I know, of my own knowledge, that he took a very active part in the discussion of the question. I have much pleasure in seconding the vote of thanks.

The PRESIDENT, in supporting the vote of thanks, pointed out the character of the South Wales coal, and the bearing this seemed to have on the quality of the coal described by Professor Dawkins as found at Dover, namely, the upper seams being a bright blazing coal, whilst the lower series were drier, and in Pembrokeshire we find Anthracite. It was, he said, very interesting to note the number of seams proved in the boring at Dover, all of which, he believed, except No. 2, were workable seams. He had known seams worked in Lancashire of less thickness than 1ft.

The vote of thanks to Professor Dawkins was unanimously passed.

Professor DAWKINS, in responding, said: I am sure I have to thank you for the way in which you have received my remarks; and I am particularly gratified in hearing what my old friend, Mr. Greenwell had to say on the subject before us. There is no man whose opinion I would be inclined to take in this matter so absolutely as I would Mr. Greenwell's. I do not know that it affects the general question very much, but, nevertheless, I certainly do think that, as a rule—at all events on the French side of the Channel—the bituminous coals are mainly massed in the upper series; and I ought also to say that upon the evidence of the fossils, a French palæontologist, M. Zeiller, has identified the beds with the series which occur at Radstock and the seams which occur in the Middle Coal Measurs of Belgium

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and Northern France. Nevertheless, I am not quite satisfied that we know enough about the range of ferns to allow of our coming to any definite conclusion on that point. With regard to what Mr. Dickinson said about two men not being able to ride one horse at once without one having to sit behind, I would say that Mr. Godwin Austin first got on that horse in 1856, and Professor Prestwich did not mount till, I think, about the year 1866 or 1868.

Professor DAWKINS called attention to the microscopical structure of the blazing coals, and stated that their quality was due to the presence of vast quantities of minute spores, chiefly of the lepidodendron. Micro-sections of this and other coals were, at a later period of the evening, exhibited in the Geological Laboratory. Referring to the collection of fossils recently added to the Museum by Sir U. Kay-Shuttleworth, the Professor said that it was only right and proper that any additions to the Museum should be made known to the Members of the Geological Society, for this very good reason—that they owed the making of that Museum to the Society, and the Society had a closer connection with that part of the Museum than any other body of scientific men had with any other part of it.

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JUL 3 1894

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XXII. SESSION 1893-94.

The ORDINARY MEETING of the Members was held on Tuesday, February 13th, 1894, at the Rooms of the Manchester Literary and Philosophical Society, George Street,

The President:

Mr. W. SAINT, Her Majesty's Inspector of Mines, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. GEORGE B. HARRISON, Inspector of Mines, 278, Brooklands Terrace, Worsley Road, Swinton, Manchester.

Mr. JOHN SLEE, Engineer, Earlestown, Newton-le-Willows.

Mr. WILLIAM BORROWS, Providence Foundry, St. Helens.

Mr. ALBERT MILLS, 95, Milnrow Road, Shaw, near Oldham.

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BOULDER CLAY NODULES AND ICE-WORN STONES.

The PRESIDENT, in the absence of Mr. Mark Stirrup, read a communication from Mr. G. H. Kinahan, M.R.I.A., on the "Singular Nodules and Ice Worn Stones from the Boulder Clay," described by Mr. William Watts. *(See Part XIII., Vol. XXII., Transactions.)*

Those stones of Mr. Watts are very interesting—we have "Coffin stones" in connection with our Coal Measure and Calp shales, they are stones with a compact envelope, inside which is a kernel that rattles, or an ochreous sand—*in situ*, that is when in the solid shales, they are solid—never taking the coffin form till the shales are weathered or the nodule is in the drift; and this to me proves that in the centre of the nodules there was some sort of easily disintegrated substance or mineral that by some leaching process was disintegrated and sucked out of the nodule. In some of the lower sandstone of Co. Limerick, there are large spheroids, that in the upper or weathered part of the quarry have compact envelopes, but rotten centres—ferriferous sand or mud. In the Calp sandstone, Co. Fermanagh, similarly near the surface, there are compact shells, from 6 to 12 inches in diameter, that contain fine sand. Mr. Watts' blood stones must in a manner be allied to these. They evidently were originally physically hard, but chemically soft nodules—on account of their hardness they resisted crushing while travelling in the drift—but as soon as they were stationary, chemical decomposition took place. But during this process, or immediately afterwards, a secondary chemical action took place; as by a leaching process, materials from the enclosing matrix, fixed the margin of the disintegrated nodules, and grew gradually

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into an enclosing, hard, envelope. This undoubtedly is what took place in the generation of the "Coffin stones."

If the Brick clay, mentioned by Mr. Watts, is the detritus of Lias Coal Measure shales, they originally would probably have in them, layers, lentils, and nodules of marcasite. This mineral is physically hard, but chemically soft—in the ice mill it would not be ground up but only rounded—in its bed of clay it would decompose, while the leaching of calcareous matter from the clay matrix would form round each centre a shell of impure chalybite.

It is a pity Mr. Watts has not stated the chemical compositions of the envelope, and of the "blood;" I suspect the latter would contain a trifle of sulphuric acid.

In our Lower Coal Measure shales there are thin layers of a pyriteous clay-ironstones, and when these shales are weathering, the seams form layers of "Coffin stones" of all manner of shapes. The core, or "corpse," when you break the coffin is often, in aspect, exactly similar to a worked stone chisel, and on the Aran Isles, Galway Bay, in old times, these were adapted as "skinners;" they being the proper shape, and to make a skinner of them, all that was necessary was to sharpen the broad end. Some specimens of these adapted nodules were in the Geological Museum, Queen's College, Galway. Some years ago I was asked to inspect a collection of implements and human remains collected in the province of Munster. These were fossil human bones, and pre-historic or rather pre-Adam implements. The skulls were large nantillii, with the whorle broken off. The leg and arms were those large branch corals from the carboniferous limestone, very like human limbs; while all the implements were from the pyriteous layers in the basal Coal Measure shales. Some of these were really good, as for instance a "hammer head," with the hole for the handle.

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Although you can collect from one of these weathered Coal Measures, or Calp shales, a collection of "pre-historic implements," yet all such implements must not be condemned as frauds; as the primitive inhabitants adapted stones that they found suitable. In fact this is done at the present day in places in Ireland. There is a dish-shaped stone found in the mountain stream, Co. Donegal. In these the mountaineers run a trade, as they punch a hole in the narrow end, and sell them to the farmers in the lowlands as rollers, or rather crushers for breaking the clods on the potatoe and turnip drills, for which they are most suitable; as the dish-shaped surface can be run in the hollow, and the other on flat surface on the drills. In West Mayo I saw a primitive wooden plough that had for a coulter a triangular piece of quartzyte chipped on the edges, and for a shear a piece of highly silicious micalyte; both were adapted sea-worked stones, selected from a shingle beach. On Aran Galway Bay, I have seen sheep and calves skinned with an adapted Coal Measure nodule. Near Gorey, Co. Wexford, there is an intrude of doleryte, so jointed that it breaks up into chisel-shaped pieces; so all that is necessary to form an implement is to sharpen the chisel end, and chip the handle a little. Curious, in New Zealand there seems to be a doleryte with similar peculiarities; so much so, that when I exhibited the Wexford implement, all the authorities insisted that it was a New Zealand implement that some way or other had found its way to Ireland. Flint flakes, naturally made, may be identical with artificial ones. This can be seen at a chalk cliff, near Fairhead, Co. Antrim. In the chalk there are layers and nodules of flint; as the chalk weathers these drop out, and fall a considerable height on to a floor of doleryte. The fall breaks them up, and anyone can there collect flakes identical with the rude artificially man-made flakes.

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As to the polished and striated pebbles, these to me seem easily explained. A few years ago a great fuss was made over some many-faced striated pebbles brought from India, one of which is in the Dublin Museum, and I believe a second is in London. The explanation of the appearance of these pebbles is quite apparent. Ice action never cut the surfaces. Naturally the jointed structure of the rock broke it up into fragments, of the shapes that are now found; while one of the numerous polishing processes supplied the polish and striæ. In the drift of any Calp district in Ireland, some Calp beds breaking up such forms, I could procure nearly similar shapes. For polishing, etching, and striation it is not necessary to call in the aid of ice. Put a fragment of rock in a clay that is accumulating on a slope. The clay as a mass has a sliding motion down the place, as can be ocularly proved by the crushing of the lamination. The matrix moves faster than the inliers, which consequently are turned about as the matrix moves forward; while the movement of the clay acts similarly to a putty polisher, and each particle of grit in the clay acts as an engraving tool.

The carriage of the big blocks, mentioned by Mr. Watts, does not necessarily prove a normal glacial formation. I know a block at least half a ton weight that was carried across a bay in Lough Ree, Co. Longford, by comparatively thin ice. It apparently was lifted by the ice, before a storm came, which drove the ice across the bay, and with it the blocks of limestone after the "break up." In Canada I have seen very large stones carried down the mud rivers on very small rafts of ice, to be deposited in silt as in tiers. These great flows of mud, from a few yards to miles in width, due to the melting of the snow, must have wonderful polishing powers.

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Mr. WATTS said: I think the thanks of the Society are due to Mr. Kinahan for his valuable communication, and I beg to propose that our thanks be given to him. I will afterwards make a few observations upon the paper.

The motion was seconded by Mr. DICKINSON, and passed.

Mr. WATTS said: I think we ought to take the remarks of Mr. Kinahan as coming from a very clever geologist, whose communications to this Society from time to time are very valuable. I regard Mr. Kinahan's paper more as an extension of my own observations than any criticism of the remarks which I was privileged to make at a meeting of this Society a few weeks ago. He certainly has offered the best solution of the formation of the nodules that I have heard. It was my idea, at the time I discovered them, that they must have been floated and deposited in a solid condition, and that then the interior had been absorbed by some means into the clay matrix in which they were buried. It seems to me that Mr. Kinahan entirely bears out that idea. The peculiarity of the thing is that we should have an extremely hard fossil case, in some instances little more than one-sixteenth, in others about an eighth of an inch in thickness. Why these hard cases should remain and the interior be gone is yet a puzzle to me, and I do not think that Mr. Kinahan has quite cleared that up. With regard to the nodules being found perfect in the hard shales, I think he is right. Those of you who know the valley know that the Lower Coal Measure shales crop out all over the district, and the particular clay in which these nodules were found is clay formed by disintegration of the Lower Coal Measure shales. That is undoubtedly the case. With regard to the chemical composition of the nodules, I can give no information; but I may say that the semi-liquid contents, which were deep-red (hence the name "blood-stones" given them by the workmen), in some cases,

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if the nodule was fairly large, ran fully 18 inches or 2 feet along the slope of the ground when the nodule was cracked. As to the polishing, I am not quite sure that we have all the knowledge we require with reference to this. These nodules were something more than polished; they were burnished, and I do not think Mr. Kinahan offers a sufficient explanation in supposing that they lay upon a solid surface whilst the clay matrix washed over them. In that case, I think, you have an element of erosion coming in. This would not have the effect of burnishing the nodules; it would tend to rub down the angles, and that would be about all. Mr. Kinahan has made some observations with reference to that little implement, or supposed implement, which I exhibited. However, I had given that idea up after the remarks of Mr. Dickinson, who has very kindly given me a specimen of cannel coal, which is very much like my own. It certainly is not polished, and the edges are not so sharp as in my own, and if I were to draw a comparison between the two, I should say that my own is more like a human implement than a natural piece of cannel that has these peculiar angles formed *in situ*. With regard to the millstone-grit blocks, which is the last subject contained in Mr. Kinahan's communication—of course, it may be, as Mr. Kinahan says, that these blocks have been floated from the upland beds lower down into the valley, and there I found them underneath the clay which covered them. It would not be an ordinary piece of ice that would do a thing of that kind; and, then, on the margin of the Pennine slopes you must have ice sufficiently strong and sufficiently thick to grasp those blocks, and subsequently to float them down the stream. But before you can have ice accumulating in that way, to carry out the suggestion of Mr. Kinahan, you must first of all be clear that there was a lake in that particular valley. A mountain stream, by itself,

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would not be sufficient to accomplish the work, unless you were to assume barriers thrown across; and there are no lateral streams sufficiently large to throw a barrier across the main stream and dam it up. Therefore, the evidence from Mr. Kinahan's point of view is not sufficiently clear to satisfy me that these millstone-grit blocks were floated the two miles, or thereabouts, on ice which had been formed in the district. I come, then, to the original idea, that these blocks must have been brought there by the agency of ice other than the ice which accumulated in water in the district. I think I have other witnesses besides these millstone-grit blocks to bear me out. We find a number of foreign boulders. I have one now reared up in my garden fully 7ft. 6in. in height, and I suppose something like 5ft. in diameter—that has not been brought there by a mere film of ice. But, then, the whole district is rich in not only lake district boulders, but also in other foreign material, which, I feel sure, has been brought by the agency of ice and not so much by floating as by land ice. I thank Mr. Kinahan for kindly criticising—or, in other words, supplementing—my paper, and I take it as a compliment, because it comes from a very clever man.

PRACTICAL NOTES ON THE MINING OF IRON ORES, BAUXITE, &c., OF COUNTY ANTRIM.

By Mr. C. H. Williams.

Illustrated by specimens of Rocks and Ores.

(Communicated by Mr. William Saint. H.M.I.M.)

I have carefully read, with great interest, Mr. Kinahan's Paper on the Iron Ores of County Antrim. It is ably written and very instructive.

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As is now well known, the iron ore measures extend over a large portion of the county, occupying an area of about forty miles in length by about ten or eleven miles in breadth.

The formations stand in the order I have placed them in the large box of specimens sent from Ballymena, and as shown in the accompanying section (Fig. 1).

No. 1. Upper Basalt.
„ 2. Pisolitic Iron Ore, No. 1.
„ 3. Second quality Ore, or Pavement.
„ 4. Bole.
„ 5. Upper Lithomarge.
„ 6. Lower do.
„ 7. Lower Basalt.
„ 8. Chalk.

The ore bed has a moderate inclination, and the ore has been worked in numerous places.

When the lie of the bed has been ascertained, we select a point in the outcrop of the ore at the lowest possible level consistent with conveniences for loading into railway wagons. Where mechanical haulage is intended, we drive a level, 7 feet high by 8 feet broad, so as to admit of a double line of tramway; otherwise we drive our level only 5 feet broad. We either sink a shaft or drive a parallel level for purposes of ventilation. After the levels have been extended far enough into the hill to get under a steady rock cover, and the ore is good enough to work, side drifts are made right and left, and from these working places are branched off, 8 yards apart. Where the roof is not sound, pillars are left to support it, otherwise the ore is worked out on the longwall system. As a rule the No. 1 ore only is worked and sent out, the miner taking up a sufficient depth of the pavement in the roadway to admit of his hutch, which holds about 8 cwts. The pavement cuttings, along with all

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"brushings" and other rubbish, are stowed away behind the miner in his working place to aid in supporting the roof. At our Glenarm mine, in addition to the No. 1 ore, we send off the No. 2 quality ore (pavement) instead of stowing it, it being richer in iron than the average, and close to seaboard for shipment.

The analyses of the No. 1 ore from our Ballylig, Clonetrace, and Rathkenny mines show from 42% to 44% of metallic iron in the ore; that of the No. 1 ore from Parkmore, 39% to 41%. The Glenarm No. 1 ore showed 38%, and the No. 2 ore (pavement) from 18% to 20% of metallic iron in the ore.

The thickness of the No. 1 or pisolitic ore varies, the average being about fourteen inches. It does not always prove of the same density, nor with the same thickness of steatitic clay holing between it and the upper basalt. In some places the ore is very compact and adheres to the roof or basalt; in other places, patches or pockets of soft clay "holing" and "brushing" set in. In the former case, the miner under-cuts the pisolitic ore on the top of the pavement or No. 2 ore for a yard or two forward, and then brings it down by means of wedges or by blasting.

As a rule the ore found nearest the outcrop is richer in metallic iron than that obtained from the interior of the mines where the ore bed is far harder and more compact.

Dykes, of varying thickness and density, are plentiful throughout the county of Antrim, and are frequently met with in mining the ores. Some of these dykes, although strong and massive and from 30 to 50 feet broad, do not displace the iron ore bed, whilst others displace it as much as 250 feet.

During the course of my 23 years' experience in working these mines, I have never observed any change worth

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Trans. Min. Geo. Soc. Part XVII Vol. XXII
To illustrate Mr. C. H. Williams' Paper

SECTION OF STRATA.

Upper Basalt denuded, and of variable thickness.	
Pisolitic Iron Ore	3" to 3'
Pavement do	7'
Bole	10'
Upper Lithomarge	11'
Lower do.	12'
Lower Basalt	550'
White Limestone	350'

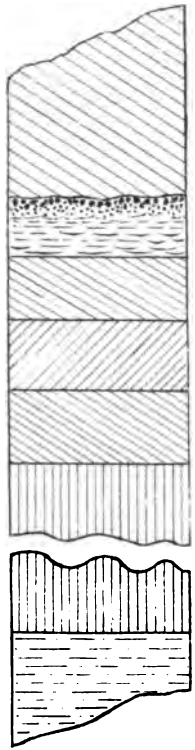
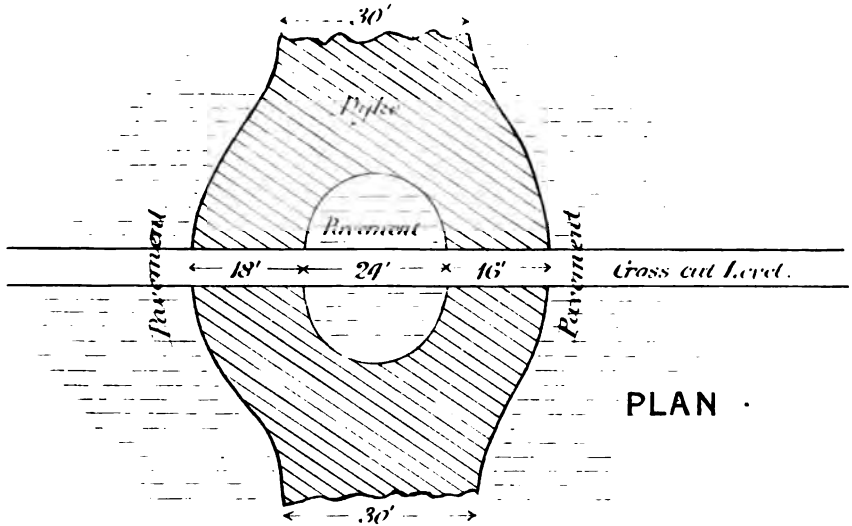


FIG. 1.



PLAN.

FIG. 2.

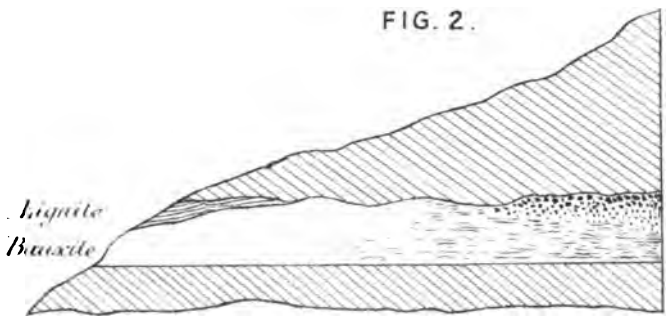


FIG. 3.

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noting in the character of the ore in the neighbourhood of the dykes.

A very singular discovery was made the other day in our Rathkenny mine. One of these dykes was met with, and three fathoms driven into the hard rock when the pavement was struck, of fair average quality, and four fathoms driven in it. Here the hard dyke rock was again met with and passed through in two fathoms four feet. A good clear pavement was here found, as shown in Fig. 2.

The length of this deposit is about 30 feet. I do not know to what depth it extends, but, judging from where the dyke was driven through in the tunnel below, it cannot be deep, probably not more than 6 feet.

Aluminous Clay *(Bauxite)*.

This material has been found in several places within our mining district, and in nearly all cases the iron ore bed gives place to it. Like the pisolitic ore, it is found situated next to the upper basalt unless it happens to be overlaid by the lignite. Of late we have proved, by means of boring, a fairly large area of the clay at the north-east end of our Parkmore Royalty. It is joined at each end by the pisolitic ore. There is a gradual diminution in the size and number of the pebbles in the ore bed, and they finally disappear as we approach the bauxite clay.

The lignite is not always found associated with the bauxite. It is frequently absent.

The lithomarge always maintains its regularity below the bauxite as it does the iron ore.

In the small box will be found specimens of pisolitic ore (No. 1), aluminous clay (so-called bauxite), and lignite—all obtained from our Rathkenny mine. Their relative positions in the ground are shown in Fig. 3.

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NOTES AND ANALYSES OF IRON ORES AND BAUXITE FROM THE CROMMELIN MINES, CO. ANTRIM.

By Mr. William Peile, Mining and Civil Engineer, Whitehaven.

(*Communicated by Mr. William Saint, H.M.I.M.*)

Your President having asked me to contribute a few notes on the Iron Ore Measures of County Antrim, I have much pleasure in furnishing samples and analyses of Iron Ore and Bauxite from the Crommelin Mines, near Ballymena, and also some particulars of their respective commercial values for the information of the Manchester Geological Society.

The specimens sent you are from the Crommelin Mining Co.'s properties, and comprise Basalt, Pisolitic Iron Ore, Bauxite (light and dark), Pavement Ore or Bole, Lignite, and Lithomarge. The mines have railway connection for shipment with Belfast and Larne, and are situate to the West of Cargan Station on the Ballymena and Parkmore Branch Railway.

The deposit worked is mostly a Ferruginous bed, interstratified with the Basalt, overlying the chalk, and extending over, or covering, the whole of the surface of the County of Antrim, except in the valleys and low ground, where it has been denuded.

The *Pisolitic Ore*, *Bauxite*, and *Lignite* or fossil wood, are, so far as I have been able to form an opinion, all found in the some position or bed, but in patches occupying considerable areas in different localities, and varying in thickness from 2 inches or 3 inches to 30 inches in places, underlying a stratified or bedded form of Basalt. The Pavement Ore,

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or Bole, is next underneath, irregular from 2 to 10 feet in thickness, and then comes the Lithomarge 20 to 30 feet in thickness, the series being subject to intrusive dykes of Trap Rock.

Owing to the high per centage of alumina contained in the *Pisolitic* and *Pavement Ores*, they have principally been used by the smelters as a flux in the blast furnaces, in the proportion of say 1 cwt. to 20 cwt. of Hematite Iron Ore, or mixed according to the quantity of alumina required. The demand has all along been limited, and the total export production, I believe, only about, and not exceeding, 160,000 tons in any year; consequently few of the mines have been worked regularly or to their full capacity.

The following are average analyses of the iron ore beds:—

	Pisolitic Ore.	Pavement Ore.	Lithomarge.
Pero. of Iron.. ..	59·40	33·34	6·61
Alumina	2·80	41·13	29·88
Silica	10·40	3·78	49·75
Combined Water ..	8·40	15·55	5·48
Other constituents..	19·00	6·20	8·28
	100·00	100·00	100·00
Metallic Iron.. ..	41·58	23·34	4·62

The *Lithomarge* contains too small a per centage of iron to make it of any commercial value. It is generally of a bluish slate colour, and has a greasy feel.

The *Pisolitic* and *Pavement Ores* are frequently sent across the Channel as ballast to consumers, and the Pavement ore, when used alone as a flux, has realized about half the price of good Hematite ore at the furnaces. Only recently it has been discovered that the Pisolitic ore will work very well in the furnace itself, and it is now more in demand for the metallic iron it contains, at a price rather better than for its

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equivalent in per centage of metallic iron in Hematite iron ore, and it is well liked and giving satisfaction.

Bauxite, as explained before, takes the place of the Pisolitic ore in the same bed, and is found in patches of small and sometimes of considerable areas, in different places.

The following table gives the qualities and prices as published by the Irish-Hill Co., Antrim, Ireland:—

	First Quality. In bulk, 20/- per ton.	Second Quality. 16/- per ton.	Third Quality. 12/- per ton.
	Dried and ground,		
	In bags, at 35/-	31/-, in bags.	27/-, in bags.
Alumina	53·83	52·00	46·13
Peroxide of Iron	1·57	4·57	15·14
Lime	·62	·79	·18
Magnesia	·13	·20	·26
Potash	·01	·02	·04
Soda	—	·06	·24
Silica	8·67	12·00	10·40
Titanic Acid	5·80	6·20	4·20
Sulphuric Acid	0·07	0·07	0·10
Phosphoric Acid	Trace.	Trace.	Trace.
Combined Water	29·27	24·00	23·39
	99·97	99·91	100·08

The above dried at 212°:—

	First Quality.	Second Quality.	Third Quality.
Moisture lost by drying	7·50	0·90	0·85

Analyses by John Pattinson, Newcastle-upon-Tyne.

The percentage of alumina contained in bauxite is variable and cannot be determined by inspection; it must be analysed. The dark or blue variety is usually found to be the best. Hitherto Irish bauxite has principally been used by chemical manufacturers in making alum cake; it is not unlikely, in the near future, that Irish bauxite may be of value in some aluminium reduction process, or as a refractory material.

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Lignite, or fossil wood, has from time to time been worked in many places throughout the basaltic area. I believe extensively at Ballintoy near the north coast. A patch occurs at Killymurris, not far from Ballymena, where the specimen sent you would be obtained.

NOTES ON BAUXITE OF COUNTY ANTRIM AND ITS USES IN THE MANUFACTURE.

By Mr. Geo. G. Blackwell.

(*Communicated by Mr. William Saint, H.M.I.M.*)

Before the year 1871, the English manufacturers were dependent upon the French and German mines for their supplies of bauxite. I am not sure who was the original finder of the Irish alum clay; but, in my opinion, the credit of identifying it with the French bauxite was due to the late Mr. Alex. Sutherland, who was one of the best Geologist and Chemists in the North of Ireland, and made the important discovery in 1870. In 1871 we became associated and having obtained, from the Marquis of Downshire, a lease of between 2,000 and 3,000 acres in the neighbourhood of Ballyclare, we began prospecting and succeeded in proving an extensive deposit of bauxite of a superior quality, containing 54 per cent. of hydrated alumina in the dry state and from 1·5 to 1·75 per cent. of iron, samples of which are now before you. At first the demand was limited to small quantities, and, therefore, the mines were opened out on a corresponding scale; but during the last few years there has been a great change in this respect, and consequently new levels have been driven and additional shafts sunk to the lower deposits to meet the increasing requirements of the various manufacturers, and the mines are now capable of yielding a large

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output—probably not less than 2,000 tons per week—of the finest quality ore. Owing to the death of Mr. Alex. Sutherland, it was found desirable to form a Company to take over the mines, which are situate at Straid, near Ballyclare, and they are now owned by the Bauxite Co., Limited, in which I retain my large interest. Large orders are received from the United States of America and Germany, and also from the various alum manufacturers, &c., in England and Ireland. The ore is used in the manufacture of paper, alum-cake, so essential in the deodourising of sewage; the fixing of colours in the manufacture of cloth; of earthenware baths; and of firebricks of a very refractory nature—indeed practically indestructible. It is also in particular request for the purpose of manufacturing the best aluminium metal, which is now being made very cheaply from this ore.

Bauxite bricks are now manufactured in France, and it is contemplated to build a large works at Larne to make them from Irish Hill bauxite. It has been proved by experimental trials that they are admirably adapted to withstand prolonged intense heat, and are far superior in this respect to the best Stourbridge and Dinas bricks.

In the early stages of the development of these mines there was a large demand for beetroot sugar, in the manufacture of which it was discovered that some 20 per cent. of sugar passed off and was lost in the waste, which up to this time was practically useless. Mr. B. E. R. Newlands, an eminent Chemist and then Manager of one of the largest sugar works in London, conceived the idea of running liquid sulphate of alumina upon the beetroot waste, which immediately liberated the sugar and transposed the potash contained in the waste into crystal alum. This became a profitable operation, as it recovered from the practically waste substance a large quantity of sugar, and at

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the same time converted the sulphate of alumina into crystal alum, which was resaleable at considerably higher figures than had been paid for the sulphate of alumina, whilst the sugar was extracted practically free of cost.

The PRESIDENT said: The papers I have read come from gentlemen who have personal knowledge of mining and of the value of the ores for commercial purposes. They are not members of this Society, and therefore our thanks are specially due to them for the valuable communications they have given us. The information will be an important addition to that contained in Mr. Kinahan's paper already published by the Society. I have pleasure in moving that the best thanks of the meeting be given to the contributors of the papers.

The motion was seconded and passed unanimously.

Mr. DICKINSON said: I would add to what the President has said that the papers will add to the value of our Transactions. I wish, however, to draw a little closer attention to some points of difference which exist with regard to two or three matters. In the first place I see, in the paper already in the Transactions, which was read at our last meeting, Mr. Kinahan quotes largely from Mr. P. H. Argall. Mr. Argall is a miner, and was for many years one of the agents at the Cronebane Mines, County Wicklow. Whilst he was there the Company began precipitating the copper from the water in the mine; some explosive gas was evolved in the process, and, being in a confined space, without any ventilation, Mr. Argall happened to notice the lengthening of the flame of his candle, which circumstance enabled him to prevent what would have been a disastrous explosion. That little circumstance attracted my notice and raised Mr. Argall to a high position in my estimation. I have watched his

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career since with some satisfaction. After the circumstance referred to he removed to the iron ore mines at Glenariff, County Antrim, and was there for some time. I have no doubt he used the best of his opportunities in observing the way in which the beds there lie, as pointed out by Mr. Kinahan, who has drawn largely upon Mr. Argall's paper. He says (in a passage quoted by Mr. Kinahan), that when the beds are all fully represented they consist of (as these sections show) lignite, alumite, or alum clay, steatitic clay, steatitic rock, pisolitic or pebble ore, aluminous ore, ochreous rock, and lithomarge. He says truly that it is only when they are all represented; but having myself been, I think, in every one of these mines which have been worked for many years past—and in some of them many times over —I may say that I never saw them all fully represented. Whether they are quite conformable one with another or not is doubtful; but, as Mr. Williams points out, where the pisolitic ore disappears the plain ore remains, and then gradually that dies out and the bauxite comes in. In some instances where this change has taken place from the iron ore to the bauxite it is not always so clear that the beds are continuous. It might almost sometimes appear that the bauxite comes and displaces the iron or, as Mr. Kinahan puts it, "leaches" it. This term "leaching" is new to me. Whether it is the same bed or not is open to doubt; but I am disposed to think, with Mr. Williams, that it is the same bed. Mr. Williams is a Mining Engineer who has had great experience as a Cornish man and in working different mines in Ireland. He has been about 20 years in charge of the Antrim Iron Ore Company's Mines in County Antrim—the largest and most numerous mines of any owner in the county; so that he has very great experience, and what he says may, I think, be taken as reliable—that this bed, as a bed of iron ore, becomes gradually transposed into the

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bauxite. The next thing I notice in Mr. Kinahan's paper is that he expresses his surprise as to the term "bauxite." "The name (he says) for some unaccountable reason has been given by Government officers in their official returns to the Irish alumite." I do not know why he should call it an unaccountable reason. The people about the mines all call it bauxite; it is sold as bauxite; it is returned as bauxite, and one of the companies for working it call themselves the Bauxite Company, as you have read in Mr. Blackwell's paper. It may be a joke possibly—if so we pass it by, and add to it also another little joke which Mr. Kinahan is making in spelling this word with a "y," making it bauxyte instead of bauxite. Similarly lignite becomes "lignyte." Geologists are rather fond of making these changes needlessly, and of leaving some of us, who are old-fashioned, a little in the lurch. Whether it is a misprint or an intentional alteration I do not know, but in the meantime I think we had better stick to the old spelling. The next thing Mr. Kinahan notices is that the dykes may be divided into two distinct classes—first, those which stop at the roof, or "stop dykes," and those which penetrate the roof, or "through dykes." Mr. Williams says that certain dykes displace the seam, and certain others do not. I think the fact that all whin dykes do not pass up to the surface of the ground is not confined to the County Antrim. Some through whin dykes of the North of England traverse long distances from west to east, and occasionally in Cleveland, do not always show quite up to the surface. They rise to a certain height and then disappear. Other dykes do come to the surface; so it seems to be a thing which is common in these whin dykes. There is another thing in Mr. Kinahan's paper which I think will puzzle some miners. He says "there is nothing new in a horizontal lode." I think there is. He

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thinks it possible this iron ore bed may be a horizontal lode. Now the lodes, or veins, as we all know, are fissures which travel across the bedding of stratified rocks; and this bed of iron ore is a thoroughly stratified bed. He quotes Mr. Henwood as his authority on horizontal lodes; they are called "lay and lay." It may be so in some districts. In Cornwall there is a lode which is called the Flat lode—it has an angle of perhaps 45 degrees; and in nearly all our mineral lodes there is a variation in the lay, sometimes from perpendicular down to an angle of 45, varying according to the hardness or softness of the strata through which they are passing. But a perfectly flat lode is something new, and something that may well startle any miner. At the sides of many mineral lodes, or veins, there are layers of flat ore connected with the main lode; these are sometimes called "flats"; but they are not stratified like the pisolitic ore of County Antrim. Mr. Williams, in giving the area of this iron ore field at 40 miles by 11, must, I think, be taken as having meant that those are the distances measured right across the map from one place to the other; and does not mean it to be understood that the ore exists in the entire area, because it is absent in some of the valleys and appears only on the hill sides. Then as to the original discoverer of bauxite. I have heard the discovery attributed to many people. No doubt the late Mr. Sutherland was one who worked it out fully, and had as much to do with ascertaining the value of bauxite as anyone in Ireland. He had a knowledge of chemistry as well as mining; he was an exceedingly useful man there, and must be a great loss to the district. Long before his time there was a book written by a Mr. Hamilton, an old Trinity collegian (it is probably 100 years old), in which the author notices all these beds of ore and the peculiar minerals which accompany the iron—namely, various crystals and little accumulations of magnesia,

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partly filling cavities which exist in the neighbourhood of the basaltic rock and between that and the iron ore. This magnesia is sometimes used as medicine by the people of the district, but who really was the original discoverer of the bauxite I do not know. I have not seen Wagner's book, but Hamilton's I have seen and read. It is only recently that the value of the bauxite in the making of alum has been fully recognised. Formerly the chief alum shale was brought from the neighbourhood of Whitby, and latterly the late Mr. Peter Spence used clay extensively from the floors of the coal mines of county Lancashire, and it was called aluminous clay. It was really just one of the beds of fire clay—very different in appearance from the bauxite; and that, I think, is sufficient to justify the County Antrim people in giving their clay the name of bauxite. Bauxite, as perhaps most of you know, takes its name from the place where it was worked in France—Baux; and this Irish clay, being very similar, has taken the same name, and is sold as bauxite. It very much resembles it, and is entirely different from the Whitby alum clay or the clay worked in the coal measures.

The President: Mr. Dickinson has discussed the several Papers remarkably well. His many years' acquaintance with the Irish mines entitle him to speak with authority on the questions, and his remarks have been very interesting and instructive. Mr. Kinahan, referring to the analyses given in his Paper, states that the Irish alum-clay is "conspicuously different" from the French and German ores. It will be seen, however, that the analysis of the Irish ore is given in full, but those of the French and German ores show deficiencies varying from 3·83 to 5·30 per cent. They are, therefore, incomplete, being such as a buyer would make for commercial purposes. It is apparent that the Irish ore contains the same principal elements;

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besides, it has been successfully placed on the English and other markets as "bauxite." in competition with the foreign ores, and I think the Irish miners are fully justified in naming their ore "bauxite." Mr. Blackwell informs me that he has been down the bauxite mines in France, and that the French and Irish hill ores are precisely alike with the exception that eight per cent. of the alumina in the French ore is insoluble and cannot be extracted; whilst the whole of the alumina contained in the Irish ore is soluble; therefore sixty per cent. French ore is only equal to fifty-two per cent. Irish. By "leaching," I understand Mr. Kinahan to mean that the plants which grew on the margin of the shallow lakes, and which are now represented by the lignite, somehow "leached" or sucked the iron out of the bauxite. There is, I think, a better way of accounting for the comparative absence of the iron. Mr. Williams has shown that the bauxite is continuous with the lower portion of the iron ore bed, which, but for its excess of iron, would be identical with bauxite. It is also a fact that the bauxite is never found overlaid by the pisolitic iron ore, and, therefore, it has not been subject to the percolation of iron, except, perhaps, in a minor degree from other sources, which would probably account for the low percentage of iron which the bauxite contains. Mr. Kinahan also states that the "alumite is not found except associated with the lignite." But, having some knowledge of the Antrim mines, I cannot agree with him on that point.

Mr. Dickinson: Not always. It is sometimes, as near Ballintoy; and at Blackwell's mines there is a trace occasionally of the lignite to be seen above the bauxite.

The President: What I wish to be understood is that by far the greater part of the bauxite deposit is not overlaid by lignite, and that the latter is frequently absent even at the outcrops. Referring to Mr. Williams' section, it will

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be noticed that two beds of iron ore are shown, but in reality there is only one bed. The upper portion—No. 1 Ore—consists chiefly of "peas," which decrease in size downwards from the roof, the larger ones being richest in iron. The thickness varies, and is occasionally met with as much as 3 feet. The lower portion—No. 2 Ore—contains an excess of alumina, and appears to be suitable as a flux in blast furnaces using silicious ores, and also useful in protecting the inner lining of the furnace from any excess of lime which may be present. From the samples, it will be seen that the upper and lower basalts are similar. The lithomarge varies in colour from grey to brown; it is abundant, but it does not appear to be considered of any particular value. The white limestone is extensively quarried at Carnlough, Glenarm, and other places, and exported to England and Scotland for burning and other purposes; and at Glenarm and Larne it is largely used in the manufacture of whiting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XXII. SESSION 1893-4.

The ORDINARY MEETING of the Members was held on Tuesday, March 13th, 1894, at the Rooms of the Manchester Literary and Philosophical Society, George Street,

The President,

Mr. W. SAINT, one of Her Majesty's Inspectors of Mines, in the Chair.

METEOROLOGICAL OBSERVATIONS OF 1893, WITH NOTES OF TEMPERATURE OF MOORLAND STREAMS.

BY MR. WILLIAM WATTS, F.G.S.

Fine weather and brilliant sunshine, above the average, prevailed over the United Kingdom during the Spring and Summer months of 1893, and the year is spoken of by many as being a dry one.

The aggregate rainfall, however, is not much below the average, and is considerably above those of 1884 and 1887 respectively. What strikes one more particularly is the small amount of rainfall on the majority of the wet days and not the number of fine ones. The Piethorn gauge is placed in a central position in the valley, at an elevation of 894 feet above ordnance datum, free from obstruction and,

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therefore, admirably adapted for collecting the rainfall from every point of the compass.

The average rainfall of the district is 38 inches, but that is the record of several gauges fixed at various altitudes.

In 1893, the Piethorn gauge registered 31·23 inches of rain on 186 days, an average of 0·167 inches on all the recorded wet days, and 0·086 inches when divided by the 365 days of the year. Looking at the average in this way, the rainfall per diem seems small, and the gentle showers barely sufficient to keep the atmosphere humid. Yet floods occasionally occurred, but not sufficiently large to cause damage. There were three days only on which more than one inch of rain fell during any consecutive 24 hours; all the rest were simply showery days, when no more rain fell than sufficient to make them damp and unpleasant. February, May, and December each claim one of the heavy rainfall days alluded to, and which are shown on the diagram.

Few previous years show less rainfall during an equal number of wet days, and in this respect 1893 must be regarded as droughty, yet the number of days on which no rain fell are only seven less than the wet ones.

For commercial and hygienic purposes it is important how the annual rainfall is distributed throughout the year to serve the highest interest of mankind. As a matter of choice, man prefers genial showers at short intervals of time, and this is better for vegetation, but in our insular climate it would be unsuited in a commercial sense, as will be seen presently. Gentle showers, falling at intervals, do not largely feed the springs in the upper reaches of our country, and as rivers need springs to feed them they cannot be made to flow at a time of the year when evaporation and percolation are active, and plant life requiring a deal of

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moisture to sustain it. We have, therefore, to rely on the rainfall in the wet seasons to replenish the springs and feed the rivers.

Similarly, corporate bodies, having the responsibility of supplying a large population with water, have to fall back on an accumulated stock, or the supply would fail. It frequently happens that a dry season is estimated by the scarcity of water in the reservoirs, and not to the want of foresight in providing it by anticipating the wants of an increasing population.

On referring to the table of the yearly rainfall, it will be seen that January opened fine, and was followed by February the wettest month in the year. December coming next in the amount of downpour. March and April were the two driest months, the remaining seven months being pretty even in amount and character of fall.

With the meteorological characteristics here named, the year does not differ widely from other dry seasons. Taking the earth with its atmosphere as a unit it can be mathematically proved that of the total amount of heat received from the sun on a hemisphere of the earth in the course of a year, 63 per cent. is received during the Summer, and 37 per cent. during Winter, and that this cannot vary, notwithstanding the presence of cloud or vapour obstructing the sun's rays from any part of that hemisphere.

One is always apt to measure the comfort of a summer climate by the character of its warm and genial days, and the severity of a winter by its cold ones, rather than by the length of time the seasons last.

I am assuming that the general theory of the weather is known, as I wish to be understood, in stating that the greatest strain and heaviest weight to bear exercise their influence on the bearer, more than equalising of the burden,

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for it is the higher units of force which try men and make them remember.

Wet and dry periods seem to run alternately, but the sequences are not regular, and there is no known rule to determine them. Man is ever trying to find them out, but hitherto he has failed beyond a few limited generalisations. Storms are fickle and uncertain. They rise in the Atlantic, but in coming to Britain often get deflected, and spend their wrath in the higher regions of air and mountain, far removed from the observations of man.

Rainfall observations have been uninterruptedly made in England since the year 1726, a period of 167 years. Dr. Symons, F.R.S., informs us that during the whole of this time there was no instance of more than five consecutive years being wet until we come to recent years, and then we have the unprecedented fact of nine consecutive years each wetter than the average. The fall of rain during the last fifty years has been on the increase compared with the preceding 100 years, which seems to indicate that our climate is getting wetter.

The physical cause of this increase in the pluvial activity of our climate is not easily explained. Whatever the cause may be, the rainfall in England is on the increase, if the observations of the last fifty years may be taken as a guide.

It is most interesting to note that from 1726 to 1781 (55 years), 38 years' rainfall fell below the average, and 17 only rose above. From 1781 to 1836 (55 years), 32 years fell below the average and 23 rose above, and from 1836 to 1891 (55 years), 28 years were wetter than the average and 27 drier.

The ratio, as far as the number of years is concerned, does not appear great, but the amount of rainfall in the aggregate must be our guide.

The last half-century of rainfall exceeded any previous

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half-century records since 1726, if reliance can be placed on the old gaugings. Whether we have entered upon a long period of secular increase of rainfall no one can tell. Mr. Hopkinson, F.G.S., is of opinion that the reverse is more likely, and he infers that the heavy rainfall of recent years is simply an episode of a declining period of rainfall, if measured by centuries instead of decades, and that in the distant future less rain will fall.

The arguments in favour of this hypothesis are too learned and abstruse to be dealt with in a short communication like this on the local variations of rain, and I pass them by without further allusion.

The first forty years, commencing with 1726, nine years only reached the average annual rainfall; and if we are entering upon a drought such as then existed, the present generation cannot realise the inconvenience some of our towns would experience in a water famine.

One feature of Dr. Symons' diagram is very striking, viz., the low rainfall decades ending with a 4, commencing with 1834, and ending with 1884, making the sixth successive year which has been drier than usual, but which does not seem likely to hold good for 1894, if the wet character of the two first months of the year be any guide. I have no firm belief in the theory of cycles in physical meteorology, but the evidence of the last fifty years seems to favour the belief in recurring periods of wet and dry seasons.

The fall of rain in twenty-four hours in any part of England seldom reaches four inches, and as a rule the dry days are in excess of the wet ones. If the average yearly rainfall were distributed equally over the 365 days of the year it would not amount to one-eighth of an inch per diem.

The velocity, or rate, at which rain-water flows off the land depends on the inclination and character of the ground. Longdendale Valley, for instance, is a typical drainage area,

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of an angular and steep character, and the floods sometimes reach the rapid discharge of 38 cubic feet per second from each 100 acres, as gauged by Mr. Bateman, C.E.

The minimum discharge during a time of drought is also very interesting, and valuable information for the hydraulic engineer and others depending on the supply of water from a surface drainage area, as it represents the least possible discharge of water from the land at a time of the year when the consumption reaches the maximum and evaporation the highest limit.

From observations, I have found as small a volume as 0·40 cubic feet, or 2½ gallons per second, flowing from 950 acres of moorland, which is a very low rate, but which compares favourably with the gauging of other observers.

In making comparisons, however, of the dry weather flow of a district it must be borne in mind that the surface water parting at the ridge of the drainage area does not always correspond with the subterranean drainage. This fact has been proved over and over again, and I remember Professor W. Boyd Dawkins, F.R.S., stating in one of his many lectures I have had the honour to attend, that persistent pumping in a well for a town supply lowered the water in a second well twelve miles distance.

The depth of a valley, dip, and character of the geological strata require to be known, also the line of saturation in the bed of the stream, and whether the rocks are retentive or freely yield the water in dry seasons.

When the ground is bare, as a ploughed field for instance, rain-water percolates into it more freely than when it is covered by profuse vegetation, but such land is necessarily limited in an area, such as the hills of our country present. Ploughed fields allow a greater percentage of rain to pass through the subsoil than grass fields, and probably less evaporation rises from the stubble land, as the rain-water

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sooner escapes out of sight and out of the sun's rays and dry winds.

Subaërial denudation is an important factor which must not be lost sight of in lowering the surface of the ground, and in assisting to cool the earth and lessen the rainfall century after century.

The variation in the temperature of water and atmospheric air at different times of the day during the summer months is very interesting to notice. The changes are more pronounced in air than in water as we may expect. By way of comparison, I give below the temperature of air floating over a typical mountain stream 1,000 feet above ordnance datum, and the water flowing along the stream at the same time and place.

MOORLAND STREAM, DRAINING 480 ACRES.

Date, 1893.	7 A.M.		1 P.M.		7 P.M.	
	Air.	Water.	Air.	Water.	Air.	Water.
	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.
August 18	69·6	59·0	76·0	70·5	72·6	68·2
,, 27	51·3	52·5	57·7	59·5	49·7	54·8
Sept. 6	56·0	54·4	60·1	58·7	57·4	57·0
,, 23	38·0	42·2	41·2	45·4	41·2	43·9
October 14	55·7	50·6	58·1	54·0	58·0	54·0
,, 31	28·3	36·2	34·9	38·6	28·9	36·8
Nov. 16	38·8	39·9	43·4	43·0	40·2	41·4
,, 23	28·3	34·0	31·2	34·0	30·0	34·9

The above temperatures are taken at random, by way of illustration, from my tables of monthly records, to show the extreme variations in the space of six hours on the same day. In a small stream of water, moving along an irregular and rapidly-inclined course, it will be noticed that the temperature of the water does not vary from day to day to the same extent as the air floating above it.

Being subject to considerable aeration, by contact with the coarse stony bottom, it seems surprising that the temperature remains as approximate as it does with the air.

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I also submit a table showing the temperature of the atmospheric air and water on the same dates, observed in a 40-acre reservoir, 884 feet above Ordnance datum, and which receives the water from the 480 acres of drainage referred to above, along with that from other sources. The object I had in view, in carrying out these observations, was to ascertain, as near as could be done, what difference of temperature, if any, there is in large volumes of water at rest and the feeders that supply it. I was induced to make these observations mainly with a view of ascertaining at what degree of heat potable water produces the maximum number of entomostracan creatures which swarm in the shallows, and which give rise to many complaints by timid consumers every summer. I have not been able to formulate any reliable conclusions so far, but it seems to me the cooler the water can be maintained the less active and energetic are the entomostracans in it, apart from the food supply poured into the reservoirs by their feeders. The more quickly, therefore, water can be collected from a drainage area, and passed into the reservoir formed to receive it in bulk, the better and the colder it will remain.

The observations in the following table were made at 1 p.m. each day, my object being, as stated, to ascertain the maximum temperature of the air and water respectively :—

MAXIMUM TEMPERATURE OF AIR AND WATER IN A 40-ACRE RESERVOIR, 884 FEET ABOVE ORDNANCE DATUM.

Date. 1893.	1 p.m.		Remarks.
	Air.	Water.	
August 18	78·8	67·9	Clear sky. Wind, south.
,, 27	55·8	61·4	Clear sky. Wind, south-east.
Sept. 6	61·2	61·2	Dull sky. Wind, south-west.
,, 23	41·8	53·6	Thunder and rain.
October 14	57·9	51·1	Heavy rain. Wind, south-west.
,, 31	38·7	45·9	Clear and frosty. Wind, north-east.
Nov. 16	45·1	42·8	Bright, clear sky. Wind, east.
,, 23	31·8	36·4	Snow. Wind, north-west.

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A rise in the temperature invariably takes place between 7 a.m. and midday, and a corresponding fall between 3 and 5 p.m.

A rise in temperature of all moorland streams is accompanied by a decrease in the rate of flow owing to an increase of evaporation.

The range of summer temperature in lakes and reservoirs is very variable, and in some instances unique, and between it and the winter months still more so. Water varies from 33° F. in winter to 67·7 F. in summer, and it is no wonder that low forms of life are found in it.

OLDHAM CORPORATION WATERWORKS.

RAINFALL AT PIETHORN, "COLD GREAVE," IN 1893.

Gauge, 894 ft. above sea level.

Date, 1893.	Rainfall.	Greatest Fall in 24 hours.		No. of days on which rain fell.
	Inches.	Date.	Inches.	
January	1·02	31st	0·24	13
February	4·60	13th	0·85	22
March	0·74	1st	0·27	10
April	0·71	1st	0·26	4
May	2·97	17th	1·10	13
June	2·51	7th	0·58	9
July	3·24	11th	0·66	19
August	2·33	22nd	0·41	16
September	3·01	22nd	0·65	18
October	3·45	10th	0·59	20
November	2·81	25th	0·77	21
December	3·84	12th	1·06	21
	21·23			186

Mr. DICKINSON said: I have much pleasure in moving that the thanks of the Society be given to Mr. Watts for his paper. It is a subject that will bear consideration. He has mentioned a few points by which the weather may be judged, but has very wisely abstained from introducing any established theory. He thinks that possibly there may be cycles

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of weather, but I would like to ask him if his attention is drawn to the daily diagrams which appear in *The Times* showing the temperature at various stations, and also the barometric pressure as it ranges throughout the kingdom. One peculiarity about it has struck me, and I have never had it explained (I think it must have some relation to some of the causes which affect the weather), and that is, that nearly all the barometric depressions or elevations—whichever they may be—are circular, as though they were acted upon in some manner by something which has a globular form. I watch these tables daily and generally form my opinion as to the state of the weather from them, regardless of what the Meteorological Society may publish. I suppose they have no other data beyond what they give in these diagrams and the information accompanying them. I have much pleasure in moving a vote of thanks to Mr. Watts, and shall be glad if he will give us his view on the point I have named.

Mr. Garside: I have much pleasure in seconding the proposition of Mr. Dickinson. I am sorry I was not here in time to hear the whole of the paper, but what I have heard I have been very much pleased with, and it has been very edifying.

The motion was agreed to unanimously.

The President: Mr. Watts, in reading his paper, did not explain what Dr. Symons' diagram was. I do not know whether it has any reference of value that will explain any point or not, what struck me most of all in the paper was that it is essential to the well-being of the community that we should have heavy showers of rain, and that this rainfall should not be equally distributed throughout the year; because it is apparent, from Mr. Watts' statement, that our streams and springs would be altogether wanting, or they would be so small as to be of little value either for town

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supply or for manufacturing purposes if there were not heavy falls of rain periodically. I hope Mr. Watts will be able to furnish a reduced copy of his diagram for publication in the Society's Transactions.

Mr. Watts: I shall have pleasure in getting the section reduced. I may say that the diagram has been prepared somewhat in a hurry. I have travelled from London in order to be in time to attend this meeting, and I have not had the particulars before me for a week or so. With reference to the diagrams in the *Times*, I see them very seldom; but I am aware that day by day the Meteorological Society sends to that paper particulars of the barometrical depressions at a very considerable number of stations throughout the country. As to the oscillations of the barometer, I would observe, first, that the barometer is not a weather gauge; it simply records the height of the atmosphere. The higher the atmosphere is the higher must be the barometer as a matter of course, for when we happen to be under a great column of air it sends the mercury higher up the tubes; but beyond that I do not know that the barometer is of much use to us as an indicator of wet and dry periods. Still, when it falls, we naturally expect that rain will descend, though it does not always do so. It is by no means an infallible guide. With reference to the diagrams showing the rainfall from 1726, I take the records from Dr. Symons's British Rainfall, and anyone wishing to study the result in detail will find all the facts in Dr. Symons's British Rainfall for 1892. The author, I am glad to say, is going to repeat these diagrams every second year. I have no doubt they will be very useful. I do not know that there is anything further, but I shall be pleased to answer any questions.

Mr. Dickinson said he was sure Mr. Watts's diagram when published would be a valuable addition to his paper.

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Mr. Watts: What I wanted to bring out more particularly was the great difference between the temperature of the water in summer, and also the maximum produce of a rainfall in an extraordinarily wet period, which we find to be at the rate of 38 cubic feet per second over each 100 acres of drainage ground. We take 100 acres as the limit, and we find that the greatest rainfall period has produced a flood discharge equal to 38 cubic feet per second. I thought, as it is necessary we should not only know how much we have to bank, if I may use that commercial phrase—for a person wants not only to know what his banking account is, he also wants to know how he draws his money out,—so I put down those gauges I have given you in a district of 950 acres (that is, the Castleshorn Valley, which is a typical drainage area over the Pennine chain), and I systematically measured the flow in the driest months of the year, as represented in the diagram. The driest months of the year only give 2½ gallons from the 950 acres, or 40 cubic feet per second. That is what I wanted to bring out—the maximum rainfall in flood time and the minimum rainfall over the same district in a time of drought, with the highest and lowest temperature of the water. It was the range I wanted to get at, because you in Manchester, and all the towns supplied with water from the Pennine chain, have entomostraca coming into the water—the cyclops and some others—so soon as it reaches a certain temperature, and complaints are then made of the quality of the water. I find that in winter, when the temperature gets down to from 38° to 44° or 46°, we are seldom troubled with the cyclops, but the moment the water gets over 46° and up to 50° the cyclops begin to multiply enormously, and complaints reach us from consumers. It was the receipt of these complaints that set me to work to ascertain at what temperature these creatures begin to multiply, and at what

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temperature they cease to develop, and I took, not only the temperature of the water in the reservoirs, but of the streams also which flowed into them, and I wanted, if I could, to generalise from those observations. I have not yet been able to formulate any definite ideas, and perhaps some members of this Society may be able to help me out.

In answer to Mr. Garside, Mr. WATTS briefly described the cyclops, which is a minute entomostracan, visible to the naked eye, and closely allied to the family of shrimps. They are, Mr. Watts said, perfectly harmless, and are to be found in the purest waters, their function being apparently that of scavengers eating up decayed vegetable substances which must prove injurious to consumers of the water. I have a notion, Mr. Watts said, that these creatures not only exist in the reservoirs and streams but that they also come down the pipes, and even multiply there, notwithstanding the statements of Dr. Carpenter and others that they cannot live in darkness. I have found them in wells, and they are even more numerous there, where it is dark, than in the reservoirs, except on the shallow margins of the latter. It is said that they are seldom found at a greater depth than twelve feet below the surface; but I have found them at a depth of twenty-six feet.

Mr. TONGE said that sometimes the temperature of water was considerably below that of the atmosphere; at other times, in the same spot, considerably higher; the differences seemed unusually great. He wondered if Mr. Watts had ever tried to ascertain the cause of that.

Mr. WATTS: The air is exposed to more sudden and frequent changes than water. When heat is bottled up in water it takes a longer time to be liberated than it does in air. I think you have evidence of that in oceanic waters. Everyone knows that the temperature on the margin of the sea is more equalised than it is inland, and that is on account

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of the heat being bottled up and the water giving it out more slowly. The very same conditions obtain in inland lakes.

Mr. Tonge: I was quite aware of that law, but the variations seemed so great I wondered if there was anything further to affect it.

Mr. Watts: The difference is great, but I may say my instrument is in a tin case, and it is so arranged that the observation is always taken at a foot below the surface of the water. No doubt if I gave you the reading of the upper film of water it would be found considerably higher than what I have given you in my paper.

NOTES ON Mr. DE RANCE'S PAPER ON "THE BORING FOR COAL ON THE FREEHOLDERS' ESTATE AT HAZEL GROVE."

By Mr. Joseph Dickinson.

I notice that the Paper, in mentioning the Upper New Red Sandstone "quietly resting on the basset edges of the coals," page 453, mixes up the localities so as to render them undistinguishable. Knowing them well, as I do myself, I was, on reading the Paper, at a loss to understand the description, and I was only able to make it out by referring to Mr. Binney's original text which was referred to. I there found that Mr. Andrews's works near Smedley Old Mill were correctly described as being in the valley of the Irk, near Smedley and Cheetham Vale, and not, as stated in Mr. De Rance's Paper, as being in Levenshulme, which, as many of us know, is about four miles S.E. of Cheetham Vale. The error may have arisen from an inadvertent combination of Mr. Binney's description of the shape of the Manchester coalfield as having its base at Collyhurst and

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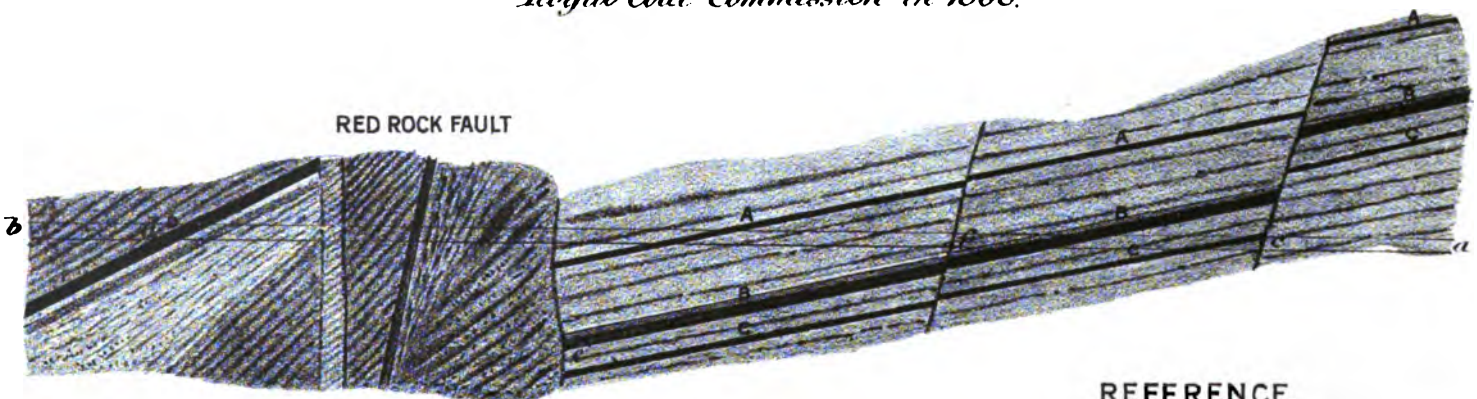
SECTION,

accompanying Mr. Dickinson's Notes being the one prepared by Mr. G. C. Greenwell, F.G.S. and presented by him to the Royal Coal Commission in 1868.



Rock col.d RED.

Shale col.d RED

Red Shales with Balls of Red Ironstone.

A Two Feet Coal

B Four Feet Coal

C Half Yard Coal

D Yard Coal not known in Poynton East of RED ROCK FAULT.

SCALE.

18 Yards to an Inch.

REFERENCE.

ab Stone Drift from 200 yard level, Park Unit Pit

c 370 yards No 80° Wt from centre d. Do.

d 106 " No 50° Wt from C

e At this point (as proved in the Four Feet Coal Level) the Coal is converted into a hard cinder.

e Down throw fault to W 7½ yards course No 22° Wt

f Do. Do. Do. Do ½ yard.

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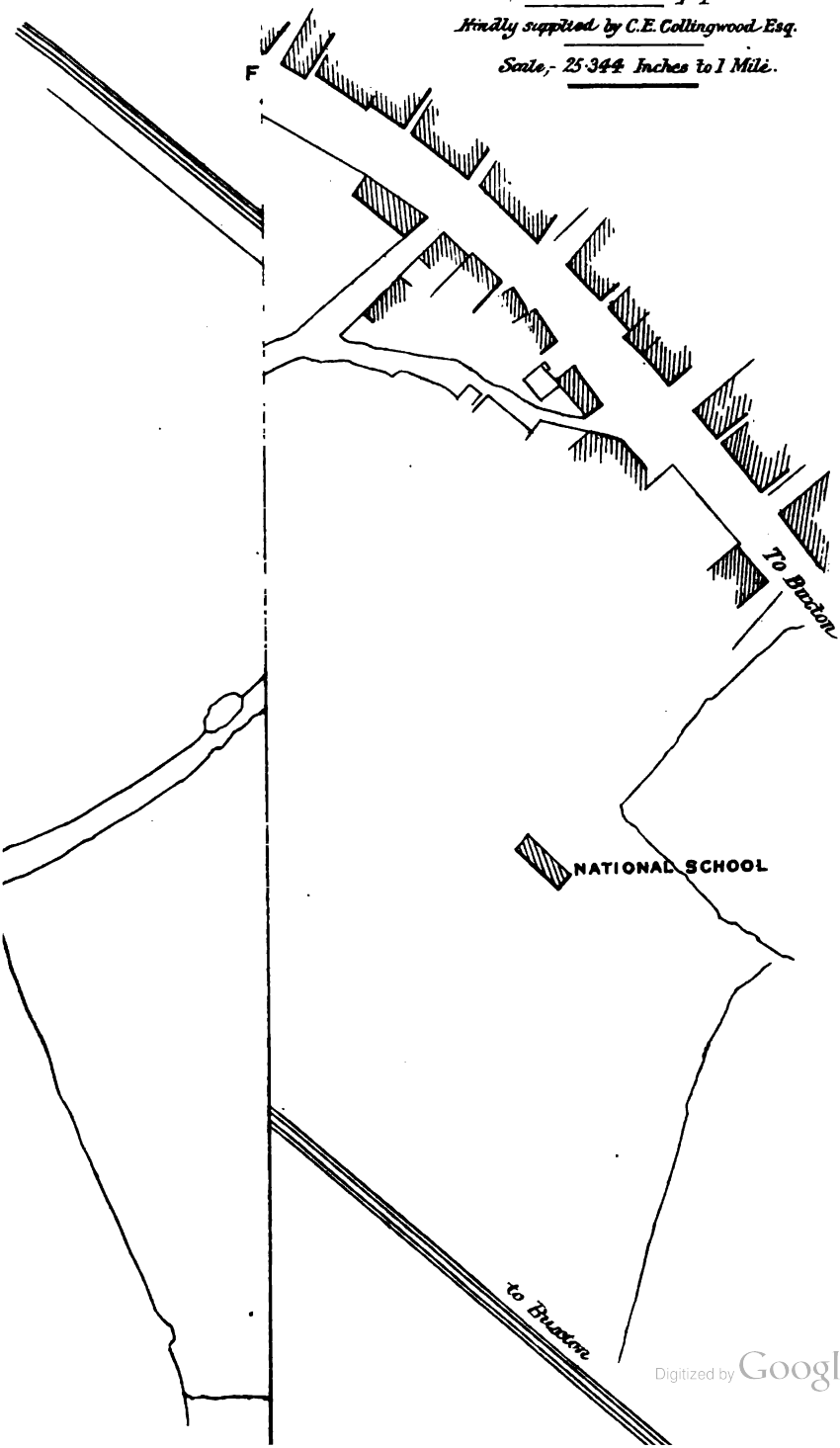
PLAN

Trans. Man. Geol. Trans. Part XVIII Vol. XXII
To illustrate Mr. Dickinsons paper.

Kindly supplied by C.E. Collingwood Esq.

Scale,- 25·344 Inches to 1 Mile.



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Smedley, and its point a little north of Levenshulme, the length being about 3½ miles; or, possibly, Mr. De Rance's numerous engagements prevented his careful correction of the printer's proof, which in ordinary course would be furnished.

What I have mentioned is important to all who study the geology of the district, and I think a corrigenda ought to be added in the Transactions. There are also a few but not very important misspellings in the Section accompanying the Paper, which might also be corrected, namely, "Bog" being printed for Big, "Shotties" in one instance and "Shutch" in another being printed for Shuttles. Mr. Binney's Paper also, I may notice, was read in 1839, the print of it being in "1841."

When Mr. Binney then wrote there had been some wrong correlating of the marls and limestones in this portion of the geological series; but his description of the overlapping agrees with what on further proof has long been accepted, and it shows how carefully that distinguished practical geologist made his observations.

The matter has not been dormant all these years. It was worked upon by the late Mr. Mellor, of the Ardwick Limeworks, who, in the Medlock Valley, in connection with the limestone mines, drove a drift between the overlapping, into which I once accompanied him, and it showed clearly the overlap at that point.

The diagram sections also which appeared in my annual report for 1858, show distinctly the overlapping.

Other persons have also given it attention. Notably, I may mention Mr. G. C. Greenwell, senr., who gave evidence on the subject before the Royal Coal Commission in 1868. He was then the agent for Lord Vernon's Collieries, in the position now filled by his son, and he described in detail the

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explorations that had been made to prove the depth to which the coalfield became covered by the overlap and dislocation, which Mr. De Rance describes from Mr. Hull's account.

I also, some years ago, mentioned to this Society some curious effects which Mr. Ashworth, the former agent for the collieries, had informed me of, that the telegraph wires of one company, which were laid under ground, became, in certain electrical states, so affected that they were allowed to be placed on poles where they crossed this dislocation; also, that damage by lightning was more frequent than elsewhere in the neighbourhood of this dislocation.

In fact it has long been known that south of Levenshulme there has been the overlap, and at some places fault as well as overlap. But the actual extent of the dislocation has not been proved. The six hundred yard fault which throws down the Manchester coalfield on the east makes its incision into the new red sandstone at Levenshulme, and other faults follow southwards through Cheshire, with dislocations and immense foldings as proved in the continuation to the northern part of the North Staffordshire coalfield.

Mr. Brockbank has, as I understand, been an active promoter of the making of the borehole at Hazel Grove. It is to it that we are indebted for the proof of the actual extent of dislocation at this point. This Society have already expressed their thanks to Mr. De Rance for the account, and to the Freeholders for allowing it to be given; and the information will be perpetuated by the print in our Transactions.

I may add that it might be useful hereafter for the purpose of drawing conclusions, if the exact spot where the borehole is situated were described; the position at present is left rather indefinite, as being only as on the boundary of the Bramhall estate, near Hazel Grove station, on the railway from Stockport to Buxton.

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The PRESIDENT said he was sure Mr. Dickinson's Notes would be a very valuable addition to the Transactions on this subject.

Mr. DICKINSON, referring to the diagram which he showed, said that it was the actual diagram prepared by Mr. Greenwell, and handed by him to the Royal Coal Commission.

Mr. TONGE moved that the best thanks of the meeting should be given to Mr. Dickinson for the very valuable addition he had made to Mr. De Rance's Paper. He did not know whether it was Mr. Dickinson's intention that the Section should be copied and printed.

Mr. DICKINSON said there could be no objection to a reduced copy being published in the Transactions. It showed what was really a very important proving which had taken place at Hazel Grove from the Coalfield on to the New Red Sandstone.

Mr. Dickinson having suggested the addition of a sketch map showing the exact position of the boring at Hazel Grove,

Mr. C. E. COLLINGWOOD, Surveyor (representing the Freeholders' Company), said he would be pleased to supply a copy of the ordnance map with the position of the bore-hole marked.

Mr. DICKINSON: It will be very desirable to have it in the Transactions.

Mr. GARSIDE seconded the vote of thanks to Mr. Dickinson, and (thanks being also added to Mr. Collingwood for his kind offer) it was unanimously passed.

This concluded the business of the meeting.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIX. VOL. XXII. SESSION 1893-4.

The ORDINARY MEETING of the Members was held on Tuesday, April 10th, 1894, at the Rooms of the Manchester Literary and Philosophical Society, George Street,

The President, Mr. W. SAINT, H.M.I.M., in the Chair.

NEW MEMBER.

The following gentleman was balloted for and duly elected an ordinary member of the Society: Mr. ROBERT H. COLE, Mining Engineer, Endon, Stoke-on-Trent.

IRONSTONE DEPOSITS NEAR DOVER.

Mr. James Tonge read the following communication from Mr. G. C. Greenwell:—

ON IRONSTONE AT DOVER.

BY G. C. GREENWELL, F.G.S.

In the month of May, 1856, I observed near to the Westbury Station, Wiltshire, a heap of stones of a dark colour, which had been laid by the side of an excavation a few yards square to form a watering-place for cattle.

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On examination of these stones, which were of uniform character, and, from the quantity which had been excavated from so small an area, I arrived at the conclusion that the bed was of considerable thickness, and from an intimate acquaintance with the Main Band of Ironstone in Cleveland I at once formed the opinion that this Westbury bed was undoubtedly ironstone, and at once sent a specimen to the late Dr. Thomas Richardson, of Newcastle-upon-Tyne, to be analysed.

The result, dated May 30th, 1855, was as follows :—

	Per Cent.
" Protoxide of Iron	45·53
" Lime	3·37
" Magnesia	Trace
" Alumina	1·40
" Silica	16·55
" Loss by heat	29·77
	" 95·62

"The difference is owing to oxygen, part of the iron "being present as peroxide. The iron as metal amounts to "34½ per cent. The stone is in fact an excellent clay iron-"stone and would make good pig-iron.

"Signed, THOS. RICHARDSON."

The colour of this stone was dark green—it abounded in oyster shells—compact and moderately hard, and where acted on by the weather, presented an incipient oolitic structure and slightly ochry appearance. The above led to further examination, and it was discovered that the bed was 12 feet in thickness; that, towards the outcrop (to the West), where only covered by two or three feet of surface soil, the ore was generally in the state of a hydrated peroxide for its full thickness, its structure being purely oolitic. The bed, which dipped to the East under the

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Kimmeridge Clay, has been proved over a considerable area.

A company was soon formed, who erected blast furnaces, which have since been continuously at work.

The general section of the immediate district is—

	Ft.	In.
Chalk		
Green Sand		
Purbeck and Portland Beds		
Kimmeridge Clay		
Coral Rag		
Ironstone	12	0
Greenish-blue Sand with Oysters, &c.	4	0
Light-brown sand	2	0
Blue Pisolitic Limestone with beds of Marl and Sand not particularly recorded	52	8
Blue Rock	1	0
Blue Quicksand with a little Water	1	0
Hard Blue Rock	1	0
Ditto, shelly	1	0
Blue Sand	1	6
Hard Blue Rock	1	6
Loamy Blue Sand with large, hard Concretions	14	6
Blue Marl	8	10
Rock	0	9
Sand	0	9
Jute, Blue Rock, with Water (20 gallons per minute)	0	6
	103	0
Oxford Clay		

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Some two or three years after the above discovery at Westbury I was at Weymouth, where I found brickmaking was carried on extensively between the town and the Chesil Beach, the Kimmeridge Clay being the material used, from which I obtained characteristic fossil remains. This induced me to explore the coast to the East of Weymouth, where I found, as I expected, a clear indication of the Westbury Ironstone, and, beneath it, of the Oxford Clay with its unmistakable fossils.

About the year 1863 I visited Abbotsbury, and inspected the enormous deposit of the Coral Rag Ironstone, first, I believe, observed and enquired into by my late and much respected friend, Mr. Charles Moore, of Bath.

The Westbury and Abbotsbury Ironstones, I have come to the conclusion, are analogous, and from the description given by Professor Boyd Dawkins of the 12 feet stratum of "Millet-seed, or Brown Oolitic Ironstone," I have no doubt that it is in the same stratigraphical position, and identical with them.

As to the correlation between this deposit with the iron ore long since worked in Sussex, I leave to others to determine. I think that the Westbury iron ore underlies that which was worked at Seend, in the neighbourhood of Devizes, and which probably is referable to the Green Sand.

The Sussex Ironstone ceased to be available from the want of material with which to smelt it, but should the ironstone of Kent prove of value, there does not appear to me to be any good reason why that beautiful county should not, in the no very distant future, enjoy the busy prosperity of Staffordshire, South Wales, Scotland, and Cleveland.

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Professor Boyd Dawkins said: I have listened with very great pleasure to Mr. Greenwell's communication, and I am very well satisfied that I have been somewhat the cause of that communication being made. Since I read my Paper I have examined Westbury in very considerable detail, and I can verify absolutely the accuracy of the statements as to thicknesses, and so on, which Mr. Greenwell has given us. I am particularly pleased to find that from his observation and experience he has arrived at the same conclusions as those stated in my Paper—that the Ironstone in the boring at Dover occupies exactly the same position in the rodes as the Ironstone at Westbury and that at Abbotsbury. Mr. Greenwell has alluded to the Ironstone of the Weald. The Ironstone of the Weald of Kent and Sussex has nothing to do with this. It is of a totally different nature; it belongs to the Wealden series of rodes, instead of what, I venture to consider, is the Kimmeridge Clay. I am particularly gratified with the interest attaching to these layers of Ironstone Ore, and all the more am I pleased and interested because the thing had been ignored till I took the matter up. In the official section, published by the Engineer of the undertaking, I see he calls it the "Millet-seed Sandstone." I think, however, when the analysis is complete (and I hope to have it before very long to bring before the Society) we shall have a different story to tell.

On the motion of the President, a vote of thanks was passed to Mr. Greenwell for his very interesting communication.

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NOTES ON HURD'S PATENT PNEUMATIC ELECTRIC COAL CUTTING MACHINE.

By Mr. Joseph Crankshaw.

The President of this Society (Mr. Saint) in his address at the opening of the present Session on "Recent Improvements in Mining Machinery and Appliances," mentioned the fact that coal-cutting machinery had not been adopted on a large scale in this country, and it seems strange that while machinery is superceding manual labour in so many branches of employment, and while we are doing all that we possibly can to improve our appliances for picking, screening, cleaning, winding, and hauling the coal, and ventilating and lighting the mine, the actual tool for getting the coal, namely, the collier's pick, is practically what it was a hundred years ago.

I do not know of any more exhausting and laborious work than holing or undercutting a hard seam of coal. The miner's body is in a constrained and unnatural position, particularly in a thin seam and the head being close to the floor, the worst atmosphere of the working place impregnated with coal dust must be inhaled. Besides the marked and disfigured faces of many of our men, especially those working in hard seams such as cannel, prove how little they can protect them from splinters whilst "holing" the coal. At the same time they are also at a great disadvantage, and sometimes get trapped in the case of a sudden fall of roof or coal.

I therefore think that not only for the sake of economy, but in the cause of humanity, it is a reflection upon the enterprise of Lancashire men that there is not a single coal-cutting machine at work in the Manchester district to-day,

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and I venture to bring the subject before this Society, not from any special knowledge I have upon the subject, but in the hope that it will, if only to a very feeble extent, stimulate thought upon it, and also in response to the hope expressed by the President, at the close of his address, that some of our members would bring before us for discussion papers on some of the subjects he had briefly outlined.

In considering the subject of motive power for coal-cutting machines, we have three methods of driving to choose from, namely, steam, compressed air, and electricity. But the heat from steam and the difficulty of dealing with the exhaust in the workings practically reduces it to two, namely, compressed air and electricity. There is much to be said in favour of compressed air. It is safe, and helps to cool and ventilate the workings, but the loss in transmission owing to friction in the pipes and leakages, is very great: the useful effect of the best engines being not more than 40 per cent., and frequently much less. On the other hand, the useful effect of a well-designed electric plant need not be less than 60 per cent. The cables occupy little space, and they can be laid down expeditiously. The current can therefore be generated and transmitted with greater economy as compared with compressed air, and now that the danger from sparking has been successfully overcome, in the manner presently to be described, it may be safely applied in any mine. Moreover, by applying an electric motor to drive a coal-cutter, it is practicable to construct a most powerful, and, at the same time, compact machine; and, therefore, I think it is the most convenient and economical power for the purpose.

Hurd's Pneumatic Electric Machine is a novel combination of the two forces. It has the advantages of compressed air, while the motive power is electricity, and taking the

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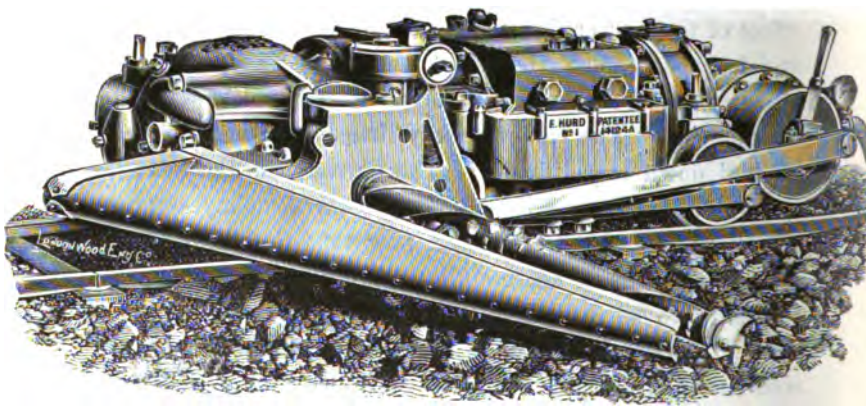
mechanism and motive power together, I consider it decidedly the best machine that I have seen.

Mr. Hurd is an engineer of very large experience in mining machinery. He has brought out numerous patents, and for the past twenty years has devoted a great deal of both time and money to improving coal-cutting machinery. He has brought out several previous machines that have done good work, but he claims for the present machine, that it is far ahead of anything that either he or anyone else has perfected before.

Briefly stated, the machine consists of a cutter-bar drill and an electric motor, connected by suitable gearing, as shown by the following woodcuts:—



Machine as seen at rest, showing arrangement for removing cuttings.

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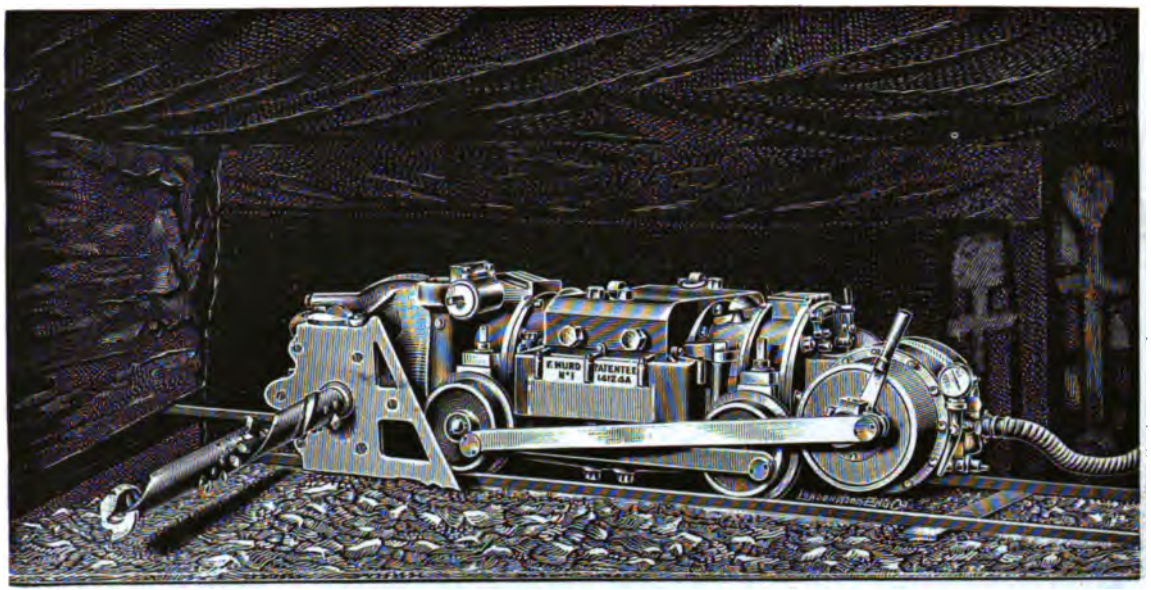

As seen in a two feet six inch. seam, undercutting at bottom of seam.

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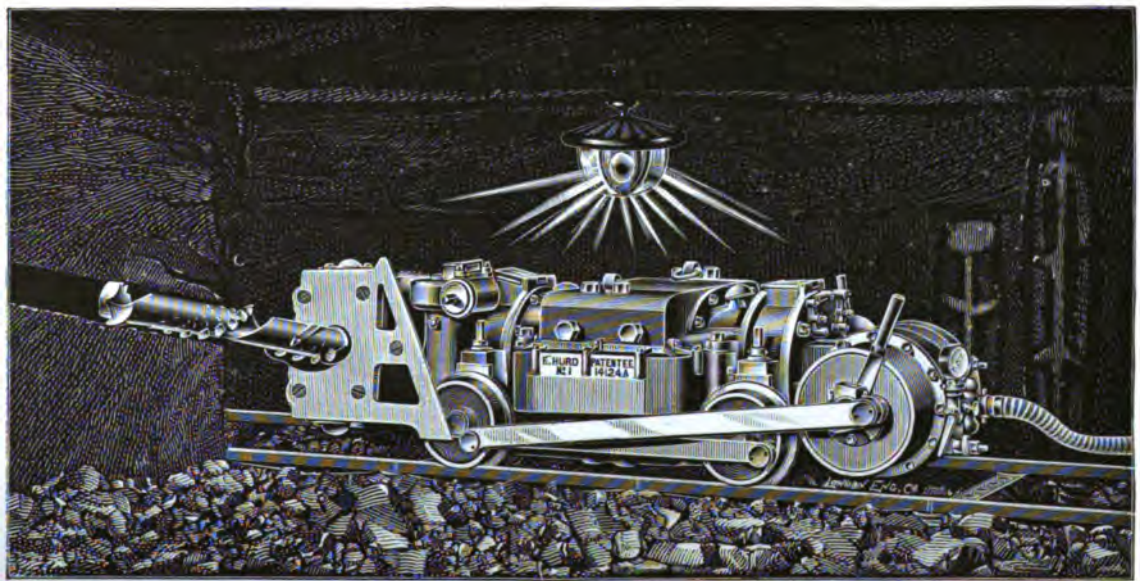

As seen in a three feet seam, undercutting in band of shale in middle of seam.

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The following extract from the provisional specification will explain the mode of working:—

The Coal-Cutter.

A combined, forged, or cast steel cutter-bar drill, with separate chilled steel or chilled iron cutters fixed on its end and along its fluted or twisted periphery, is actuated by the motor; the cutter-bar drill is caused to revolve and reciprocate in a twisted or rifled sleeve having a key cast in it which fits the fluted or twisted cutter-bar drill; the sleeve forms the wheel-boss, by which it is driven through suitable gearing from the motor shaft. The driving wheel may be cast or keyed on the sleeve or wheel-boss.

The cutters are fixed to the cutter-bar drill in the following manner:—

A number of dove-tailed recesses are formed at intervals along one edge of the twisted groove, and holes are drilled from such recesses transversely through the bar. The cutters are formed to fit the recesses, and they are retained in position by a split-locking shank, which may be separate from or attached to the cutter; the head of the split-locking shank, when this latter and the cutter are made in one piece, springs into a counter-sink formed at the outer end of the transverse hole. The end-cutter is of augur form slightly modified.

In using the machine the operations are as follows:—

When the machine is brought up to the face of the coal or mineral to be operated upon the cutter-bar drill is set in motion, and while revolving it is fed into the face by an automatic or hand feed-motion, in which latter case a circular or screw rack is cast or cut on the cutter-bar, or otherwise combined therewith, a pinion being arranged to gear into such rack.

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When the cutter has entered to the depth required it is locked by the reciprocating motion, and all strain taken off the feed gear; the reciprocating motion is obtained preferably by forming on the sleeve a worm thread, into which gears a worm wheel, carrying on its gudgeon two crank pins which actuate two rocking levers. Fitting round the sleeve, between one or more shoulders, is a thrust block in halves, each half being coupled by a right and left hand screw; these divided thrust blocks are connected to connecting rods or rams operated by the rocking levers, which impart the reciprocating motion of the latter to the cutter-bar drill when the thrust block and drill are connected.

The machine is mounted upon wheels and rails, and is traversed forward along the face of the mineral by means of a snatch block and a hauling drum, chain wheel, or connecting cranks and rods, mounted on the axis of a switch, the casing of which latter is fixed to the front trunk of an electric motor, and the hauling drum or chain-wheel and connecting cranks and rods are driven from the motor shaft by means of worm gearing and friction cones.

The cutter-bar drill at the same time revolves, thus cutting away the coal in front of it while its reciprocating motion assists in breaking up the coal and dislodging any lumps of pyrites that may be met with.

In order that the coal or mineral may be nicked on end to expedite the breaking down of the mineral when under cut, the cutter-bar drill, with its sleeve and feed gear, are carried by a separate casting carrying the bearing for the motor shaft, and which is so arranged as to make a whole or partial revolution round the motor shaft.

By this arrangement the machine is also enabled to cut either right or left hand, thus dispensing with the costly left-hand cutting arrangement as required in other machines now in use, and invented by Mr. Hurd. In this class of

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machine the vibration when at work is very great, but this is greatly reduced by fixing or constructing the journal to carry the cutter-bar drill at an angle of about 80 degrees with the rails in the direction in which the machine is moving, thereby causing the machine to hold itself well up to its work.

The machine is also provided with rail slide blocks in addition to the usual wheels, and when at work these blocks are let down on to the rails, and by their large bearing surface give the machine more stability and greater steadiness. The wheels and blocks are provided with screws for raising and lowering them, and so varying the height or angle of the cut. One set or pair of wheels or blocks and their respective raising screws are attached to a separate casting made free to revolve, or partly so, round the outer portion of the leading trunk of the motor, and are thus capable of adapting themselves to any unevenness of the rails on which the machine works; another set or pair of wheels or blocks with their screws are fixed or coupled to the back trunk of the motor.

To take out the small cuttings made by the cutter bar drill a cleaning scoop is used, preferably U shaped in section, set at an acute angle to, and behind the cutter bar drill, and fixed to the machine by suitable means when at work. The cuttings are caused by the forward motion of the machine and the reciprocating motion of the cutter-bar to slide along the face of the cleaning scoop and are deposited between or at the side of the rails as the machine proceeds, leaving for the undercut coal a clear, free space to drop when required by the fillers for loading into tub wagons. The small coal cuttings can be delivered automatically into bags at the end of the cleaning scoop as the machine moves forward.

Irregularities are removed from the face of the mineral

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and from the floor by means of a fixed cutter attached to journal casting of the cutter-bar drill, the said fixed cutter forming at the same time a cover for the thrust lock gear. This fixed cutter has a cutting edge to clear the bottom, and an inclined cutting edge to remove projections on the face of the mineral sufficiently high to clear the cutter bar bearing. The fixed cutter is also formed with an inclined groove so arranged as to carry the cuttings back over the cutter-bar front journal to the rear of the machine. By this means the machine is enabled to proceed with its work without stoppages for the purpose of clearing the road.

In using the machine for tunnelling or sinking, a slight modification is necessary; in this case, the cutter-bar drill, with or without its reciprocating motion, is fitted to the end of a telescopic arm carried by a centre casting which is free to revolve around the end trunk of the motor in a plane at right or other angles to the motor shaft.

The cutter-bar drill is tapered down from its driven to its working end; it is driven by shaft and bevel gearing from the motor shaft, and is fixed to the telescopic arm at such an angle that the tips of the cutters are located slightly beyond the plane of the driving wheel and make a cut parallel to the motor shaft; by this means clearance is obtained between the bevel pinion on the cutter-bar drill and the sides of the shaft or tunnel.

By the centre piece which carries the telescopic arm is also carried an externally rifled tubular drill which is driven from the shaft driving the cutter-bar drill.

The mode of operation of this machine is as follows:—

The machine is brought up to the face of the mineral and the centre drill and cutter-bar drill set in motion. The two drills are then fed into the face by the entire machine being worked forward by means of hauling and snatch block or connecting rod gear to the full depth required.

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The centre drill is then stopped from rotating, and the centre casting, carrying the telescopic arm, is caused to revolve by means of worm gearing driven by hand or from the motor shaft; thus the cutter-bar drill is caused to cut a deep circular, oval, or square groove in the face of the mineral; this groove may be made of any desired shape by fixing a suitable template or cam on the trunk of the machine, by which the length of the telescopic arm may be varied, and thus enable it to cut a square, oval, rectangular, or other shaped groove.

The centre drill, being allowed to remain at full depth, serves to steady the machine, so that no other stay is necessary.

When a complete revolution has been made by the telescopic arm carrying the cutter-bar drill, the drills are withdrawn from the mineral by the machine being moved backward away from the face of the mineral, which is then broken up by wedges or by blasting to the depth of the cut, the centre hole greatly facilitating this operation.

When the material is removed the machine is brought up to the face of the mineral again and the operation repeated.

The Motor.

The danger from working an electric motor in an explosive atmosphere has been overcome by Mr. Hurd in the novel manner which gives his machine the name of "Pneumatic-Electric." The motor and all its moving parts contained between the trunks of the before-described machine are enclosed in neat insulated casings, which are both air and water tight. The wires conveying the electric current are enclosed in 1½in. wrought iron pipes having junctions at intervals along the working face, and to which is attached alternately as the machine proceeds a flexible tube, which also conducts a supply of compressed air from the

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surface, and which enters the machine along with ends of the cables. The motor is thus immersed in a bath of cool, dry compressed air, which is kept constantly passing through every part, and is discharged into the atmosphere of the mine at any desired pressure, thereby effectually preventing air or dust from the mine getting into the machine, and as it escapes it helps to cool and purify the air in the working.

The coal-cutting mechanism is detachable, and the motor can then be used as a locomotive for hauling the coal along the main roads.

The Generator.

At collieries where electric and air-compressing plants are already at work, the motive and ventilating power can be taken from them; but Mr. Hurd has also patented a direct-acting engine for driving the dynamo, and an air pump for the compressed air is worked from the same shaft, so that the whole of the power and ventilation for the machine can be derived from the same self-contained engine.

The Road.

The inventor has also designed special rails for the machine, which are made of malleable cast-steel, in one yard length, and with steel sleepers. They are very strong, and have a patent joint so that they can be taken up and relaid very quickly.

The machine is about 4ft. 8in. long, 2ft. 6in. broad, 1ft. 3in. high, and weighs about two tons, and, as a whole, has a strong, compact, neat, workmanlike appearance, and gives one the impression of being able to stand the rough usage of the mine from ironstone nodules in the coal, and to falls of roof at the face, without much damage, and I think

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the inventor is to be congratulated upon his success, and may justly claim for it the following advantages:—

(1.) The machine not only undercuts the coal at any angle to the machine, but nicks on end, and will cut either right or left hand.

(2.) The drill can be speedily withdrawn to renew the cutters, and another as quickly inserted.

(3.) The holing is not reduced to an impalpable powder, to pollute the atmosphere of the workings and make it more inflammable, but much of it is in the form of saleable nuts.

(4.) The self-acting scope fills the holings into bags straight from the face.

(5.) The danger from sparking is effectually overcome.

(6.) The exhaust air helps to ventilate the mine.

(7.) Electric lamps can be attached to it for lighting the working place.

(8.) It can be used as a locomotive.

Mr. Clegg Livesey moved and Mr. Garside seconded a vote of thanks to the reader of the Paper, which was unanimously passed

Mr. Hurd, the inventor of the machine, who was present by invitation, added some descriptive details, and went on to say: The machine is calculated to cut a yard per minute in medium hard coal. It does that easily. In most coals it will do much more, in others it will do less; but we have every reason to believe that that will be the result from a machine brought out two years ago of the same kind, but without the combination of compressed air and electricity. The cutter bar of this older machine is very inferior to that of the machine described by Mr. Crankshaw. It consists of a plain bar with ordinary steel cutters. These are very expensive, costing 1s. 3d. each, yet they pay. These cutters

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of the new machine cost just one farthing each, and the difference in the cut is that the machines in use at present produce more dust; whereas from the cast-iron cutter of the new pattern we get saleable nuts and no dust. Not only so, but we are enabled, with one-fourth the number of cutters, to get along easier. It takes less power to put the cutters into action. The power is absorbed in keeping the cutters up to the face of the coal, and we find that, by reducing the number, the coal, as separated by the cutters, does not get pounded up. We do not use a hauling chain on a level roadway. When cutting down-hill the machine is so arranged that its locomotion is the same as in a locomotive on the railway, with two coupled wheels. When cutting up-hill we have to substitute a chain, in order to overcome the friction. The machine would not be heavy enough to drag itself against the cutting action and up-hill as well. In that way we get up-hill just as well as if we were on the level.

The PRESIDENT: Will you tell us where you get your compressed air—where the supply comes from?

Mr. HURD: The compressed air is generated at the dynamo on the surface, and the tubes are carried down in the ordinary way.

The PRESIDENT: Have you any machine like that at present in operation?

Mr. HURD: The photograph now shown represents the first machine made of the new type. This machine has been purchased for a company who are working mines in Tonquin. They have had experienced engineers to test it, and to see everything about it, and they have bought the patent, and have formed a company. The machine will be shipped off to-day. But we have eight other machines working with compressed air that have been at work since

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November, 1891. They are similar to this, except as regards the cutter. They are not capable of doing the right and left-hand work, but are adapted for undercutting.

Mr. Dickinson: Mr. Crankshaw, in his paper, stated that about 40 per cent. of the indicated horse-power of the engine was utilised by the air engine. I would like to know if that is based upon actual experiment. I never but on one occasion indicated an air engine to ascertain the proportion of power which it was utilising. My friend, Mr. Atkinson, indicated the steam engine at the same moment as I indicated the air engine, and we found that about 19 horse-power of the steam engine utilised barely 2 per cent. of the air engine—a very different proportion to what is stated in the paper. But that, I may say, was with the pit machine, which was first introduced at Leeds, and I have no doubt that the pit machine, with its back and forward motion, would utilise much less power than one of those rotary engines would utilise.

Mr. Crankshaw: A very much lower useful effect was obtained in your case than I gave. In order to get 40 per cent. horse-power from an air engine you would need 100 horse-power in your steam engine. I believe it is generally accepted that 40 per cent. useful effect is the most that can be got from an air engine.

The President: I think 30 per cent. is the usual figure.

Mr. Cockson: In the paper surprise was expressed that coal-cutters had not been more extensively adopted, and the speaker thought, considering the position of the collier and the arduous nature of his work, these machines would be of great advantage. I think there are several gentlemen here who, like myself, have tried coal-cutters, and it is not for want of either trying or spending money on coal-cutting machinery that such machinery has not become

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general in this district. The fault has lain heretofore with the inventive genius of mechanical engineers, who have not yet found a coal-cutter capable of working with the bad roofs and other natural difficulties in English mines. I have never seen a coal-cutter yet sufficiently adapted to work the bulk of the mines in Lancashire. That coal-cutters have not been more largely used is due entirely to these natural difficulties. The main question is—What is the best practical machine? Mr. Hurd's appears to be a very good one, and I shall be perfectly willing, subject to the question of finances being arranged, to try it in one of our mines.

Mr. Dickinson: I was hoping to see Mr. Garforth here to-day. He has a coal-cutting machine very successfully at work in collieries under his management at Normanton, and in a paper just read upon the subject by Mr. Woodward these machines are referred to. It appears they have had their difficulties. They first found that their cut was not deep enough, and they had too much difficulty in getting the coal brought down. They then increased the depth from about 3ft. to 4ft. 3in., and found that they could work successfully, and with a considerable saving on the cost of getting the coal—I believe fully 6d. a ton. As I understand from Mr. Garforth, he has had the cutter increased to between 5ft. and 6ft. with great advantage. But persons introducing machines of this character must not be deterred by little difficulties—they must surmount them. It is strange, as stated in the paper, that a county like Lancashire, which has some of the finest machinery in the world, should be so deficient in coal-cutting machines. They were tried at the Bridgewater Collieries, but abandoned after a time. Messrs. Thomas Fletcher and Son had one of the Stanley Heading Machines, which they used in heading out one of their collieries, but

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having finished that I have not heard that they have re-introduced it. The United Alkali Company also have a Stanley Heading Machine at work at their salt mine at Preesall. But with these exceptions I do not know of any machines at work now in this neighbourhood, unless it be the machines which are working successfully in the rock salt mines in Cheshire.

Mr. Hurd having made a few further remarks,

The President said: I am sure we have all listened with very great interest, both to the paper and also to the remarks of the inventor of the machine. It appears to me to be a very compact apparatus, and a good practical piece of mechanism, and I hope Mr. Hurd will meet with more success, even in Lancashire.

FURTHER NOTES ON BOULDER CLAY NODULES AND ICE-WORN STONES.

By Mr. William Watts, F.G.S.

In reference to Mr. Kinahan's notes on the remarks I made on the reading of his paper on "Boulder Clay Nodules and Ice-worn Stones," I have one or two additional observations to offer.

In the deposition of clay the water must be at rest and not in motion, otherwise re-assortment takes place. An object, similar to a nodule, is moved forward by jerks in flood time, and not regularly as the water moves, as Mr. Kinahan's note implies. A mountain stream, subject to floods occurring at intervals, never deposits clayey matrix only in the protected shallows, and into which objects much heavier than water do not find their way unless pushed there by the force of a flood, and at such times the clay is

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likely to get disturbed and some of it carried away in suspension of the water.

Snow, such as falls on the slopes of the Pennine chain, never congeals sufficiently hard to be able to carry heavy burdens in suspension; besides the idea infers deep water slowly rising from below and thus floating it as an angry flood rushing on, would not account for the phenomenon suggested by Mr. Kinahan. Drifted snow is nearly always granular, and is more compact and heavy than flaky snow which falls when the air is still. Even where drifts of snow exist in a narrow ravine the water flows on under them silently and unseen, and when the floods rise they do not come with a rush, but increase in volume steadily as the water has time to collect from the drainage area, and in this way the snow arching over the stream is made larger to meet the demands of the flood.

Snow barriers in the Pennine Valleys, in my opinion, are never formed only when a snow "slip" occurs, which is seldom, owing to the rough character of the ground formed by the action of water moving down inclined ground.

When the ice has broken up on the margin of a reservoir I have sometimes seen it carry away stone beaching, but during the whole of my thirty years' experience I have not known ice to form on a deep reservoir more than 11½ inches in thickness during one winter.

When a thaw sets in we all know how readily ice absorbs the warmth present in the air, and how soon it gets rotten and breaks near to the beach or shore. I am of opinion, therefore, that for the transportation of heavy boulders and blocks of local grit buried in the drift of the Pennine valleys we shall have to look to other than mere local agencies to account for them, and I know of no other more physically likely than ice which has been many years in accumulating,

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congealing, and slowly moving on the surface of the land radiating from a higher and common centre.

I am obliged to Mr. Kinahan for his courteous remarks and valuable suggestions.

FURTHER NOTES ON METEOROLOGICAL OBSERVATIONS OF 1893.

By Mr. William Watts, F.G.S.

Agreeably with the request of the President and other members of the Society, I have much pleasure in furnishing a reduced copy of four diagrams I used to illustrate my paper at the time it was read.

The diagrams illustrating the daily rainfall I cannot, with advantage, further reduce, and as it is forty-two inches long it is too large for reproduction in the Society's journal. There is less need, however, to illustrate, diagramatically, the daily rainfall throughout the year than the diagrams which I have reproduced. My monthly chart and table will, I hope, suffice, and if anyone wishes to proceed further, let him try the experiment of showing to the eye three quarters of an inch of rainfall spread over thirty-one days and he will not find straight to be "the line of duty" or curved "the line of beauty" on a small scale.

By way of comparison, I have prepared two diagrams to illustrate the rainfall of a wet and a dry year respectively, and also shown how the aggregate amount of rainfall in each year is dealt with by Corporate bodies owning water-works for the supply of large towns.

1886 was a wet year, producing 45·32 inches of rain, and 1893 was a dry year, yielding 31·23 inches only.

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Before a Corporation is allowed to appropriate for its own use water from a drainage area, it is compelled by law to provide storage for compensation for the riparian owners, in round numbers, to the extent of one-third of the available rainfall. When the amount has been once fixed by Parliament it remains permanent, whatever the conditions of the season may be, wet or dry.

To show the advantage, therefore, of ample reservoir room being provided, I have prepared the two columnar diagrams which epitomise 45·32 and 31·23 inches of rainfall respectively.

During the wet year it is seen that 15·77 inches of rain from the total drainage are available for the town supply, whilst 4·03 inches only are available in a dry year.

Evaporation and flood loss remain constant factors, or nearly so, inasmuch as they are based on a series of years' averages. In dry weather, however, the rate of evaporation increases, at a time when the supply is reduced to a minimum and the consumption to its maximum, and it is then when the pinch is felt.

I have tried to make my tables and diagrams as simple as possible, and trust they will be understood by everyone.

The subject of rainfall, strictly speaking, is not a geological one, but there is no known agency more efficient in eroding, transporting, and re-arranging geological strata than water, and in my paper I have tried to deal with some of the physical laws which model the undulations of the earth's surface on which we live and form the lines of beauty and add joy to our lives.

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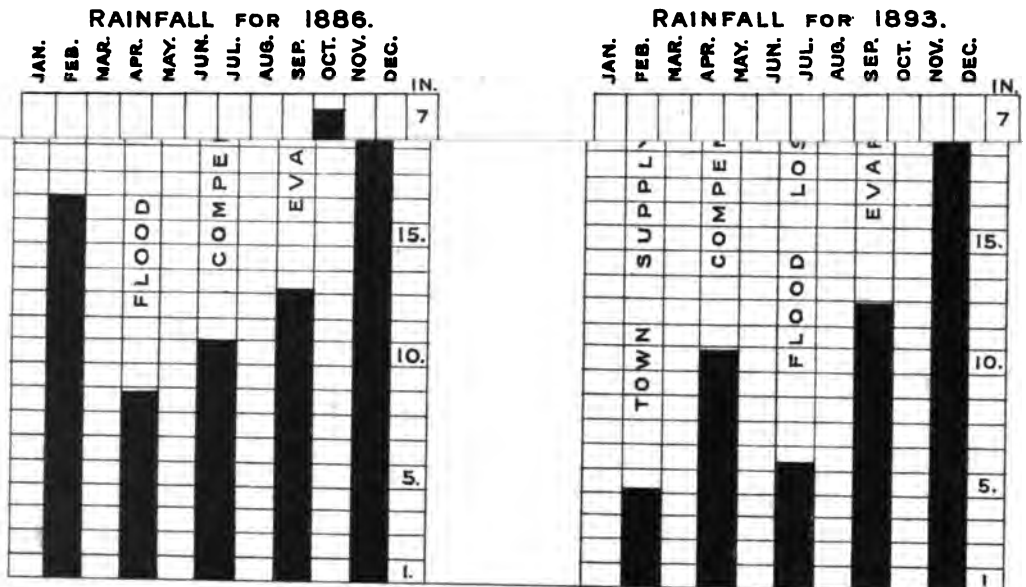
DIAGRAMS TO ILLUSTRATE Mr WATT'S PAPER.
METEOROLOGICAL OBSERVATIONS OF 1893.



EPITOME OF THE RAINFALL
FOR 1886 AND 1893.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XX. VOL. XXII. SESSION 1893-4.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, May 11th, 1894, in the Mining School, Wigan.

Mr. D. F. H. MATTHEWS, Assistant Inspector of Mines, in the Chair.

NEW MEMBERS.

The following gentlemen were unanimously elected members of the Society:—

Mr. EDWARD BRADSHAW, Manager, Great Lever Colliery, Bolton.

Mr. GEORGE RIDINGS, Mossley Common Colliery, Boothstown.

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THE WALKER INDESTRUCTIBLE FAN.

The CHAIRMAN said the next business was the discussion on Mr. Higson's paper read at the last Wigan meeting. They had a good paper from Mr. Higson, who must have taken great pains over it, and seemed to have gone into the matter thoroughly. He did not know whether Mr. Higson had anything to add, but if he had they would take it before the discussion began.

Mr. HIGSON: I have nothing further to add.

Mr. DEAN said he should like to say a few words with regard to Mr. Higson's remarks about the amount of coal used per horse power per hour for furnace ventilation. He was candid enough to tell them that there were no furnaces at the collieries under his charge, but, from the information he had gathered, he had put down that a fair amount was 50lbs. per hour per horse power at the bottom of the shaft. After seeing that he (Mr. Dean) went into the matter rather carefully at the pits in his charge at Standish, where they had four furnaces in operation, and he found that 50lbs. was nothing like the amount he got. The average of the four furnaces was 20·84lbs. of coal per horse power per hour. The pits varied in depth from 279 to 606 yards, and the amounts of coal used varied considerably between the worst and the best. At one pit they got the ventilation done with a consumption of 12·55lbs., and the worst, with regard to consumption, was 37·35lbs. He thought the cases Mr. Higson had got must have been some of the worst. There was not the slightest doubt that fan ventilation was much superior to furnace, and he did not hold out furnaces against fans; but he thought it was only fair to the furnace that had done such good work that no statement should be

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allowed to go forth which did not represent its fair work. He might add that three of the four upcast pits were rather wet, and therefore against furnace ventilation.

Mr. Tonge: Was the horse power calculated from the volume of air and the water gauge?

Mr. Dean: Yes.

Mr. Cockson said he was not present at the meeting at which Mr. Higson read his paper, so that he had not the opportunity of joining in the expression of admiration that it drew forth at the time. It seemed to him to be a most elaborately drawn up paper, fully describing the construction of what was undoubtedly an improved type of Guibal fan; and he joined with the members in thanking Mr. Higson for bringing forward the subject so thoroughly and in such a concise form. He thought they could express an opinion which would not be contradicted, and that was that the figures Mr. Higson had given them as to furnace *v.* fan ventilation, and the reduced figures Mr. Dean had given, proved that as far as economy went, apart from the question of underground safety, fan ventilation was by far the most economical the cost of the fuel being only from one-fourth to one-sixth of that of furnace ventilation. He could not find fault with Mr. Higson for not mentioning a fan which he (Mr. Cockson) had something to do with twelve years ago, but he must claim credit that before the Walker fan was brought out he patented an alteration which as effectually stopped the vibration as the Walker acting shutter. He was not finding fault with what other fans had accomplished, but was only stating it had been done before, and the way had been described to the Society. Turning to Mr. Higson's figures, and seeing how they compared with the normal Guibal fans, or even the fan of his altered type, he was struck with certain discrepancies which no doubt had

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not been made with any idea of overrating the capacities of the machine, but they had crept in, and he thought he could prove they made the results higher in the question of useful effect than they ought to have been. He then produced figures to show that the Walker fan had a useful effect of something like 64 or 65 per cent. (a very good result), but he contended it did not give as high a water gauge as a Guibal fan would give under ordinary conditions and at the same periphery speed. A 30 feet Guibal fan of the old construction, or one of his own type, would produce a 3 inch. water gauge at 64 revolutions per minute with the normal condition of the mine, and taking that as his basis, he found that the speed was 6031 feet per minute, against 6378 from the fan at Messrs. Stone's Colliery, or a speed over what one would have anticipated from a fan of the Guibal construction of 347 feet per minute, which represented 4½ revolutions of the fan at the same water gauge. That might be due to some error in the results, although he could not think it possible, or to the peculiar construction of the fan itself. On these two points he was at issue with Mr. Higson, and he thought it better to point them out, so that it might lead to some modification of the Walker fan, and enable it to give even yet better results.

Mr. Leech said he should like to say one or two words about that admirable paper. What struck him more than anything in the paper was the point that Mr. Dean had already made. He was always under the impression it was utterly impossible to compare the efficiency of a fan at one pit with the efficiency of the furnace at another, because it depended to a large extent on the length of the airways. Again he thought it was impossible to lay down a standard of efficiency in the way of fuel for a furnace, because the fuel used per horse power per hour in the furnace must of

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necessity depend on the depth of the shaft. If they had a shaft of 100 yards the quantity of coal used per hour must be greater than the shaft 1,000 yards deep. He should like to ask Mr. Higson how he arrived at the figures of 40lbs. of coal, for in the experiments he had made with furnaces his figures agreed more nearly with those given by Mr. Dean. He did not deprecate the fan, but the furnace should have its due.

Mr. Higson said in his paper he carefully avoided comparing the fan they had with any other type of fan. When they put the fan down they considered what they were going to do, and they put down what they considered the best fan that money could buy. The fan had been largely adopted up and down the country, and he had not heard of any Guibal fan superseding it yet. With regard to the accuracy of his figures, anyone who had experience of reading water gauges with high velocities knew that it was exceedingly difficult to read to a small fraction of an inch on account of capillary attraction and oscillation of the water in the tube. If instead of taking 3 inches as the correct result they started with 6 inches and worked back to 3 inches they would find that an infinitesimal error at 3 inches would account for the difference in the useful effect which Mr. Cockson had pointed out. If he were to see a number of results of observations tabulated and varying in exact arithmetical progression he should look upon them with a good deal of suspicion. The main point to be got at was to obtain as high a useful effect as possible. He had given the useful effects they had obtained, in order that any member of the Society might compare them with the useful effects obtained by other fans, and base his views accordingly. With regard to the consumption of coal, he said 50lbs. was not an uncommon amount, and the way he arrived at that was by making enquiries amongst his friends who had

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charge of efficiently managed collieries, and whose pits were as deep as theirs. He did not think the difference Mr. Cockson found in his figures was inexplicable. The periphery speed was of minor importance if they got increased efficacy and increased useful effect. The object of the fan was to put the greatest possible amount of air into the airways for the power generated by the engine.

Mr. Dean said it might add a little light to what Mr. Cockson had mentioned with regard to the speed of the Walker fan if he told the speed they got with theirs at Broomfield Pit, Standish. Under ordinary conditions the fan was worked at 75 revolutions per minute and got a water gauge of 3·3 inches, so that the water gauge would not be wide of 3 inches at 64 revolutions. That might throw a little light on the comparison of the fan.

Mr. Harrison said that the water gauge taken at the furnace would in most cases not be correct, and gave an illustration of a water gauge 50 yards from the pit bottom, the shaft being 360 yards deep, giving a reading of $3\frac{2}{10}$ when the water gauge at the fan only gave $2\frac{2}{10}$, the difference being due to the shaft columns and the difference of temperatures.

Mr. Tonge said if Mr. Higson had not made the few remarks about the quantity of coal used in furnaces there would have been very little discussion. He thought everyone admitted that the fan was a good one, and the description of the experiments was very good indeed. With regard to the quantity of coal used not much had been said on one point. Perhaps there was not such a great variation in anything as in the quality of coal. Some coals were only worth one-half or one-third as much as others, and the cost and not the weight of coal should have been given.

Mr. Cockson said the whole of his point was that the results of the experiments as recorded by Mr. Higson did

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not give the normal water gauge of the Guibal fan or the Guibal fan of his altered type at the same speed. Mr. Dean bore out the figures he had given, and he maintained that the Walker fan was not in this respect as efficient as the ordinary Guibal. He proposed that the discussion be adjourned.

The CHAIRMAN, who seconded, said there were a number of Walter fans amongst the collieries he had visited, and they seemed to give the greatest satisfaction.

The motion was passed.

The CHAIRMAN read the following paper by Mr. C. M. Percy :—

MECHANICAL VENTILATION OF MINES AND WALKER'S "INDESTRUCTIBLE" FAN.

BY MR. C. M. PERCY.

(Being supplementary to Paper read by Mr. C. H. Higson at the January Meeting, 1894.)

There is no difficulty in expressing a very high opinion of the Walker "Indestructible" Fan. It is well designed and well constructed, has long ago passed beyond the region of experiment, and is now doing very excellent work, passing large volumes of air with a high useful effect, in various parts of the United Kingdom. The makers, not content with making a good fan, have bestowed especial care in an important point which is often too much neglected, namely, the fan engine. I can well understand the hesitation which mining engineers and colliery proprietors have in adopting economical appliances in winding engines, with which the safety of hundreds of thousands of persons is so directly

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associated every working day; and no economy will justify any possibility of lessened safety which may result from complex machinery. But with a fan, we have, with its constant running, and uniform work, every inducement to, and facility for, economical appliances. Fan engines should always work compound and condensing, and thus accomplish the maximum amount of mechanical work with the minimum consumption of coal. The amount of coal consumed each year at collieries is appalling, amounting probably to more than six per cent. of the total output, and very substantial reduction might be effected. Economy in colliery operations is becoming increasingly necessary; I have suggested where some economy might be applied. The ventilating fans now in general use would appear to divide themselves into two classes, namely, the open running and the closed running. By open running I mean those which are free to discharge the air all round the circumference, and by closed running I mean fans working in a casing, spiral or otherwise. We have at the present time excellent examples of both kinds. The advocates of "open running" contend that any hindrance to the free discharge of air must entail a loss of power. The advocates of "closed running" argue that air discharged from a fan is discharged at considerable velocity, representing energy of motion, which cannot be usefully employed in open running fans, and represents so much work lost, which can be calculated in horse power, represented by the weight of the air in pounds per minute multiplied by velocity in feet per second squared and divided by 64, and again divided by 33,000. They contend that a casing, spiral or otherwise, delivering into an evasee or expanding chimney, converts the energy of motion into energy of pressure, and so absorbs it usefully. They contend that a theoretically efficient fan should discharge the air from the upcast exactly as the air is received into the down-

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cast shaft. With regard to the fan itself, I believe that the air should be able to enter the fan easily and pass through the fan with as little mere "churning" and "drag" upon upon the blades as possible. Too much capacity of fan is undesirable, and most fans err in that respect. Too much blade area simply presents excessive blade surface, and produces resistance. The conclusions at which I have arrived are, that the combined area of inlets and the total blade surface, and the circumference of inlet multiplied by width, and the circumference of outlet multiplied by width, should represent equal quantities. Theoretically, the quantity of air discharged by a fan would be the velocity of the circumference multiplied by area of outlet. The quantity actually discharged depends upon the passages underground, and with regard to that I am bound to say, after very considerable time and study, I am unable to come to any satisfactory conclusions on which anything like practical rules could be based.

Our mining friends on the continent of Europe appear to have devoted much more time to the investigation of these matters than the mining engineers of the United Kingdom. One very eminent authority, M. Murgue, has laid down what he terms an "equivalent orifice," by which, for purposes of comparison, he reduces the areas of the air passages in the mine itself to corresponding areas or orifices in thin plates. He tells us that when this orifice is altogether closed, a perfect fan would produce the theoretic water-guage representing the periphery speed; and that when the orifice expands to infinity, corresponding to working in the open atmosphere, the water-guage will disappear, and be absorbed in the resistances within the fan itself. But another eminent Continental authority, M. Hanarte, comes upon the scene and points out that M. Murgue makes no allowance for difference of proportion of perimeter to area

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in different sized orifices. For example, an opening 10 feet square has perimeter to opening 40 to 100, whereas an opening 4 feet square has perimeter to opening 16 to 16. M. Hanarte falls back upon the argument of M. Guibal, who compared mines by "temperament,"—that is to say, according to the volume of air per second which a mine would pass with, say, 1in. water-guage. I am inclined to agree with M. Hanarte, but I am not quite clear how we are to arrive either at the equivalent orifice or the temperament. I need scarcely say that the actual useful water-guage should be taken as the air is entering the fan,—that is, in the drift,—because if we take the water-guage too near the fan some of the water-guage is expended in overcoming the resistances within the fan, and not available in producing ventilation. M. Hanarte has introduced a fan which works within a concentric casing, and discharges into a chimney of somewhat peculiar shape. After leaving the fan, the passage contracts, embodying the principle of the *vena contracta* that a passage of diminishing capacity will deliver a greater volume than a parallel passage, the length of the passage being within certain limits, and the angle of diminution being also fixed. Then the chimney, which is continuously circular in horizontal cross-section, expands in vertical section parabolically. And suspended in the chimney is an obduration, which, by raising and lowering, will increase and diminish the capacity of the contracted passage to suit an increased or diminished volume.

I am sorry not to be able to add much to the discussion of so important a subject. I simply express the ideas that have occurred to me. Nothing can prevent the onward march of mechanical ventilation. The furnace, with any advantages, has many defects, and will soon become a relic of the past. Mechanical ventilation is capable of being made practically a perfect system. And a great deal of the

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perfection depends on excellent construction of fan and engine, such as that with which Walker Bros. are so eminently identified. The special advantage of good rope gearing is that the fan may run at any speed whilst the engine runs at a moderate speed; we get a noiseless piece of mechanism; the grip of the rope is so good that the strain or tension upon the ropes is virtually the turning power of the fan, and when at rest the ropes are quite slack. I do not know whether, applied to the Indestructible Fan, the Anti-Vibration Shutter of Walker Bros. is absolutely necessary, but as regards the ordinary Guibal I consider it indispensable, and substitutes noiseless and regular action for jumping and jolting, and vibration which was unsafe and made high speed impossible. My opinion is that the very large fans 40 and 50 feet diameter, which were decidedly in favour some years ago, are now becoming as decidedly out of favour, and properly so. They are needlessly heavy, occupy too much space, require very elaborate foundations, and absorb too much work in the mere turning of themselves. What we want to produce water-guage is speed of perphery, and a fan, say, 20 feet diameter will give us a periphery speed of, say, 8,000 feet a minute, as well as a fan 50 feet diameter. Then we also want capacity in a fan. A fan 20 feet diameter, and with two inlets, each 12 feet diameter, and width averaging five feet, will have capacity not less than 1,000 cubic feet and 8,000 periphery feet per minute, will have a theoretic discharging volume of over 1,000,000 cubic feet per minute, and allowing 50 per cent. for all resistances, would leave us over 500,000 cubic feet per minute. There are few collieries needing more, and if the passages in the mine are favourable, the smaller fan would pass it; if the underground passages were not favourable, the larger fan would not pass it, simply because it could not get the air. The popular, because efficient,

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colliery ventilating appliances of the future will comprise comparatively small quick running fans and compound and condensing engines. With such arrangements we may hope to produce a horse power in fan engines, with a consumption of coal not exceeding two pounds per hour. No furnace can come within even measurable distance of such a result.

On the motion of the CHAIRMAN, seconded by Mr. UNSWORTH, a vote of thanks was accorded Mr. Percy for his paper, and the Secretary was instructed to forward a letter of condolence to him on the death of his daughter.

A vote of thanks to the Chairman terminated the proceedings.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XXI. VOL. XXII. SESSION 1893-94.

The ORDINARY MEETING of the Members was held on Tuesday, June 12th, 1894, at the Rooms of the Manchester Literary and Philosophical Society, George Street,

The President:

Mr. W. SAINT, Her Majesty's Inspector of Mines, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. WILLIAM BANKS, Electrician, Bolton.

Mr. JOHN G. THOMPSON, Mining Engineer, Bamfurlong, Wigan.

SEPTARIAN NODULES.

Mr. WILLLIAM WATTS exhibited a curious septarian nodule which, he said, was one of a number of things that he had been fortunate enough to find in the boulder clay of the Piethorn Valley. Its structure was rather singular. There were a number of what he might call columns, approximately pentagonal in shape, and between the septa was to be seen a peculiarly formed crystal, the nature of which he could not explain. Perhaps Professor Dawkins would be able to throw some light upon it.

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Professor Boyd Dawkins: This is a septarian nodule, probably from the Yoredale shales. It may be a clay ironstone. The material originally deposited in the cracks has been dissolved by carbonic acid in rain water, and the cracks of the septarian have been left very much as if they had never been infiltrated at all. We have specimens in the Manchester Museum where, in some cases, the whole, or nearly the whole, of the infiltration has gone, while in some others the whole of the cracked surface of mud has been removed away, leaving the septa standing out like a honeycomb. The specimen before us is very interesting. It has been originally a nodule which, as it has become consolidated, has cracked; the cracks were then infiltrated with mineral matter, very likely carbonate of iron, and finally the infiltrating matter was removed.

ON THE GEOLOGY OF THE ISLE OF MAN.

Part I.—THE PERMIAN, CARBONIFEROUS, AND TRIASSIC ROCKS AND THE NEW SALTFIELD OF THE NORTH.

By Professor Boyd Dawkins, F.R.S.

CONTENTS.

1. *Introductory.*
2. *The Peel Sandstones and Stack Conglomerates.*
3. *Their Range along the Coast.*
4. *The Evidence as to their Permian Age.*
5. *The Drift-covered Northern District.*
5a. *The Carboniferous Limestone at Lhen Moar.*
5b. *The Triassic Sandstone at Blue Point.*
5c. *The Salt-bearing Marls at the Point of Ayre.*
6. *Comparison with other Saltfields.*
7. *The Boulder Drift.*
8. *The Rocks underneath the Drift.*
9. *General Conclusions.*

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1. *Introductory.*

The geology of the Isle of Man has not received the attention which it deserves, although from time to time small fragments of it have been described.* No geological map has been published since that of Cumming in 1848, and the accounts which have since been published are for the most part inadequate. To meet this need I have been devoting my leisure during the last eight years to making a geological survey of the Island on the 6 inch scale. I place before the Society in this communication that part of it which relates to a portion of the Island north of a line connecting Peel with Ramsay.

The *massif* of the Island consists of a great thickness of Ordovicean clay-slates, phyllites, and quartzites, riddled with volcanic dykes and penetrated by three bosses of granite, at Foxdale, the Dhoon, and Santon, and locally much folded and contorted. They form the lofty line of cliffs which characterise the greater portion of the coast-line. To the south, in the area of Castletown and Port St. Mary, the Carboniferous rocks appear at the surface, thrown down to the south-east by the Port St. Mary fault. They consist of thin sandstones and conglomerates below, constituting the natural arches of Langness, and the limestone series above, occupying nearly the whole of Castletown Bay, and the coast-line as far as Cass ny Hawin. Interbedded with this series to the south-west of Castletown are the volcanic rocks of Scarlett and Pool Vaaish, so well described by Mr. Hobson. At Peel, in the north-west of the *massif*, the red sandstones and conglomerates, grouped by some observers with the Old Red Sandstone, and by others with the

* Cumming, *The Isle of Man*, 8vo., London, 1848; Harkness and Nicholson, *Quart. Journ. Geol. Soc., Lond., XXII.* (1866); Horne, *Trans. Edin. Geol. Soc., II.* (1874), p. 323; Hobson, *Quart. Journ. Geol. Soc., Lond., XLVII.* (1891), p. 433; Bolton, *Geol. Mag., Dec., III., Vol. X.*, p. 29 (1893); Bolton, *Brit. Assoc. Report*, 1893.

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Lower Carboniferous, are also thrown in by faults, while north of a line from Kirk Michael to Ramsay, the rocks are covered by a thick mantle of drift, which forms the whole of the northern part of the Island, ending abruptly at the foot of the precipitous hills marking the line of the ancient cliff from Ballaugh, past Sulby, eastwards.

The main features of the geology of the island are identical with those of Cumberland and Westmorland. The Ordovicean strata form the *massif* in both areas, and constitute the seaworn floor upon which the carboniferous rocks rest unconformably.

2. *The Peel Sandstone and Stack Conglomerates and Breccias.*

1. The Red Sandstone series of Peel, 1368 feet in thickness, occupies but a very limited area, extending from the Creg Malin along the sea-front in a line of picturesque cliffs about one and a half miles to the north-east as far as Wills Strand, and extending inland about 1700 feet. It is thrown down to the north by the Creg Malin Fault, and to the south by that of Wills Strand, and thus is inlaid, so to speak, into the Ordovicean *massif* of the island (see map). It consists of the following rocks:—

1. The Red Sandstones (Map, and Section I.) forming the headland of Creg Malin, and covered more or less with the sand and gravel of the drift, are at the base of the series. In the cliff, and in the quarry close by, they are seen to dip at an angle of about 45° N. 33° E. They consist of a fine-grained dark red sandstone, mottled grey, reddish grey, and buff sandstone, sometimes coarse-grained, and of thin and irregular conglomerates. They are false-bedded and ripple-marked. The conglomerates are composed of pebbles of quartz, quartzite, lydian-stone, hæmatite, and red marl. Their thickness is about 426 feet, calculated in the line of the dip as far as the southern end of Trae Fogog.

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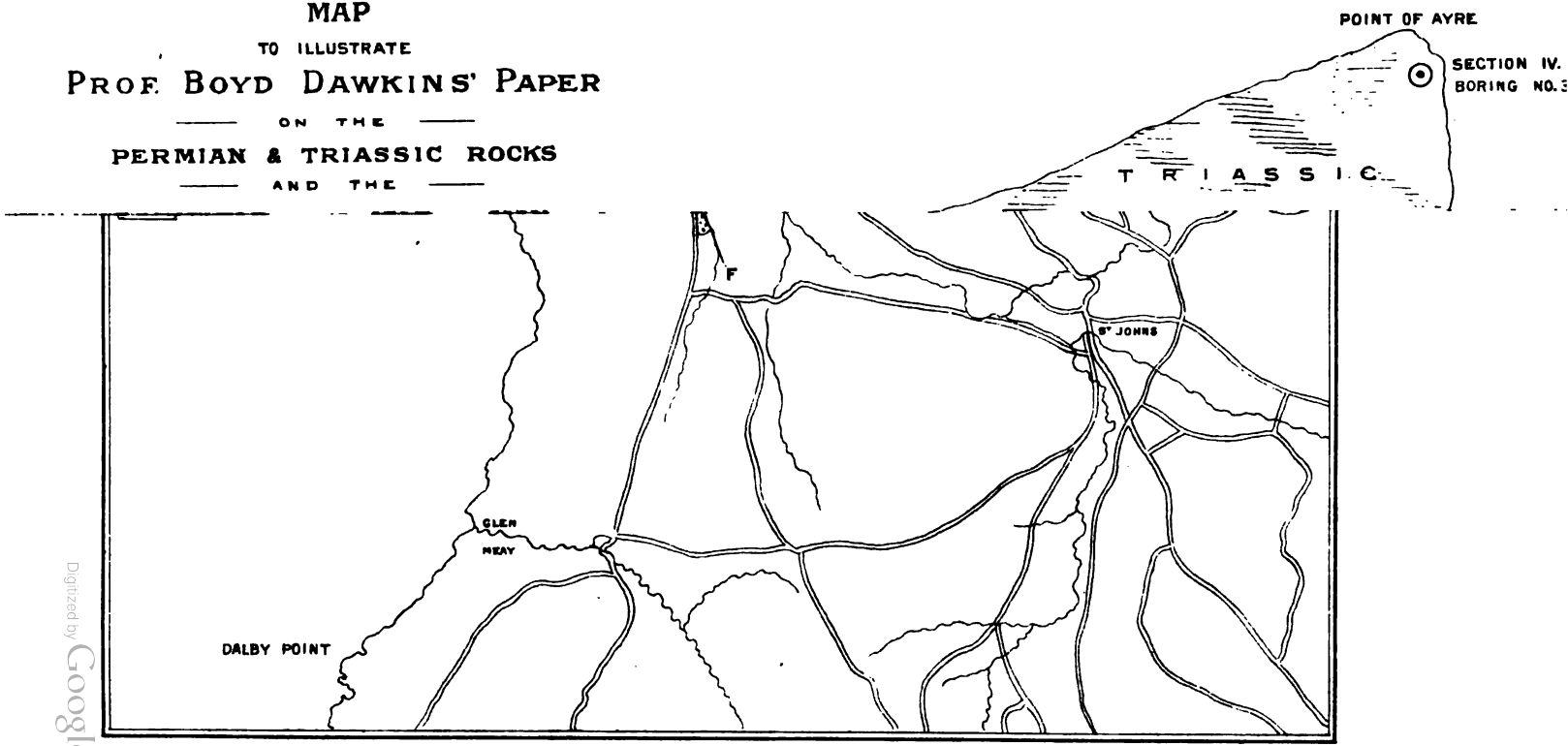
MAP
TO ILLUSTRATE
PROF. BOYD DAWKINS' PAPER
ON THE
PERMIAN & TRIASSIC ROCKS
AND THE



SCALE - ONE INCH TO A MILE.

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They also crop out from beneath the mantle of drift inland along the high road to Kirk Michael, and are extensively worked in the Ballaquane Quarries for building purposes. Here, too, they dip at a high angle of 40° N. 8° E. In this quarry the mottling of the sandstones is very striking, and may be due to fucoids.

2. The section is carried on in the cliffs of Trae Fogog, where reddish grey sandstones and irregular conglomerates, mostly composed of pebbles of quartz, quartsite, sandstone, and marl dip at an angle of 44° N. 33° E., and present a thickness of 385 feet.

3. These, in their turn, dip under the brighter-coloured red sandstones and irregular red conglomerates, with subordinate layers of red marl. There are some beds of sandstone, and the strata are much mottled in the upper portion of the series as they approach the causeway leading down to the shore. They dip 42° N. 33° E., and are 102 feet thick.

4. The calcareous conglomerates and breccias of the stack series come in at this point, occupying the whole of the sea part and as far as Lhooby Reeaste, dipping at an angle of 45° N. 18° E., gradually diminishing to 35°, and trending slightly to the west of north. They are about 455 feet thick, and are so calcareous in their upper parts that they have been used largely in former times for burning into lime.

Their sequence in the east end of Trae Fogog is as follows:—

(*a*) Conglomerate composed of limestone pebbles embedded in a red sandy magnesian paste about 10 feet.

(*b*) Bright red marls with grey spots and grey calcareous concretions about 10 feet 6 inches.

(*c*) Red sandstone faulted and slicken-sided 4 feet 6 inches.

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(*d*) Conglomerate of the same character as (*a*), about 5 feet.

(*e*) Red sandy marl mottled grey, about 12 feet.

(*f*) Irregular layer of dolomitized limestone about 18 inches thick, with irregular calcareous concretions and conglomerate with red sandstone, 8 feet.

(*g*) Bright red sandstone and calcareous conglomerates, and concretions of dolomite embedded in red paste, more than 20 feet in thickness.

The conglomerates are composed of pebbles of hæmatite, marl, sandstone, jasper, cornelians, and amygdaloidal basic rock containing chalcedony, and of carboniferous limestone. This last is more or less dolomitized, and presents traces of corals and shells, Euomphalus? Spirifer? Orthis? or Strophomena? The pebbles are imbedded sometimes in a bright red magnesian paste, and at others in a white calcareous base. The conglomerates are in places replaced by breccias of angular fragments. There are also dolomitic concretions which have been formed in a red sandy base, and are locally developed into irregular and highly-jointed layers of limestone, curiously acid-worn and honeycombed. This may be studied at the north-east end of Trae Fogog and in the Stack. The whole series is so irregular in its constitution that it is almost impossible to define the sub-divisions. It agrees exactly with that so well described by Prof. Sedgwick at Barrow Mouth, near St. Bees.*

3. *Their Range along the Coast.*

The conglomerates and breccias form the line of cliffs capped with drift from the northern head of Trae Fogog, where they are faulted to Lhooby Reeaste, where the sandstones 3 and 2 of the section are thrown in by the change of the dip from the east to the west of north. In Cass Strooan and Cains Strand the red sandstones are very much

* *Trans. Geol. Soc., Lond., 2nd Ser., IV.*, p. 395.

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mottled grey, and the mottled parts stand out in relief and resemble fucoids, as in Ballaquane Quarry. At the southern head, separating Cains Strand from White Strand, the strata are faulted down to the S.W., and the dip again passes due north, and as we approach the middle of the latter bay turns to the east of north. The calcareous conglomerates, No. 4 of section, dipping to the north at an angle of 35° to 40°, re-appear on the coast-line in the middle of White Strand, and occupy the whole of Will's Strand, and finally disappear to the north at the "Little Stack" where the honeycombed structure previously noted is seen. At this point they are thrown down to the west against the black Ordovicean shales and slates, locally stained red, by a fault passing to the south and cutting the base of the drift-covered cliffs in the south-western angle of Wills Strand Bay. The conglomerates of Wills Strand and White Strand are identical with those of the Stack No. 4, and contain the same pebbles, including the carnelians.

The Wills Strand fault may, perhaps, meet that of Peel underneath the thick mantle of drift, concealing the south-eastern boundary of the whole group of Red Rocks (see map). A reference to the accompanying map will show that these strata occupy but a very limited area to the north and east of Peel. They are a mere fragment of a great series which formerly occupied a large area in the north of the Isle of Man. They have been protected from destruction by having been faulted down into the Ordovicean *massif* of the island. They are unrepresented in any other part of the island, unless a small and obscure patch of red conglomerate resting on the Ordovicean shales, close to Raggatt to the south of Glen Faba, be grouped along with them. In that case it must be taken to represent the base of the whole series.

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4. *The Evidence as to Permian Age.*

These rocks may be divided into two distinct groups. First, the Peel Sandstone series, which includes Nos. 1, 2, and 3 of the section, and presents a thickness of 913, and the calcareous conglomerates of the Stack series, which are 455, together a total of 1,368 feet. Their true base is concealed. The pebbles of Carboniferous Limestone in the conglomerates point to a post carboniferous age, and the physical characters of both divisions are identical with those of the Permian rocks of the north of England, and more particularly with those of the Lake District, of the Vale of Eden, and Barrow Mouth, described by Sedgwick, Harkness, Binney, Eccles, and Nicholson.*

The Peel Sandstones are the equivalents of the Rot-todt-liegende of the Continent and the Lower Permian Sandstones of St. Bees' Head and the Vale of Eden. The Stack Conglomerates and Breccias represent the base of the Magnesian Limestone series of the Upper Permians and the upper (rotten) "Brockram," or conglomerate, of Mr. Binney. The thickness of the Permian rocks of the Isle of Man is more than 1,368 feet. In Hilton Beck, in the Vale of Eden, it is more than 2,000, according to Nicholson.

The presence of the calcareous rocks of the Stack series resting upon the thick Peel sandstones renders it impossible to classify the series with the Triassic strata, in which the conglomerates are below and the sandstones above. The Permians of Cultra, on the south side of Belfast Lough, described by Binney, present a similar relation of the conglomerate to the Rot-todt-liegende. It is therefore clear

* Sedgwick, *Trans. Geol. Soc., Lond., 2nd Ser. IV., 3;* Harkness, *Quart. Jour. Geol. Soc., Lond., XVIII.;* Harkness and Murchison, *Quart. Jour. Geol. Soc., Lond., XX.;* Binney, *Trans. Manch. Lit. and Phil. Soc., N.S., XII.*, p. 257, *XIV.;* Eccles, *Trans. Manch. Geol. Soc., XX. 31;* Nicholson, *Geology of Cumberland and Westmoreland*, 8vo, 1868, p. 81.

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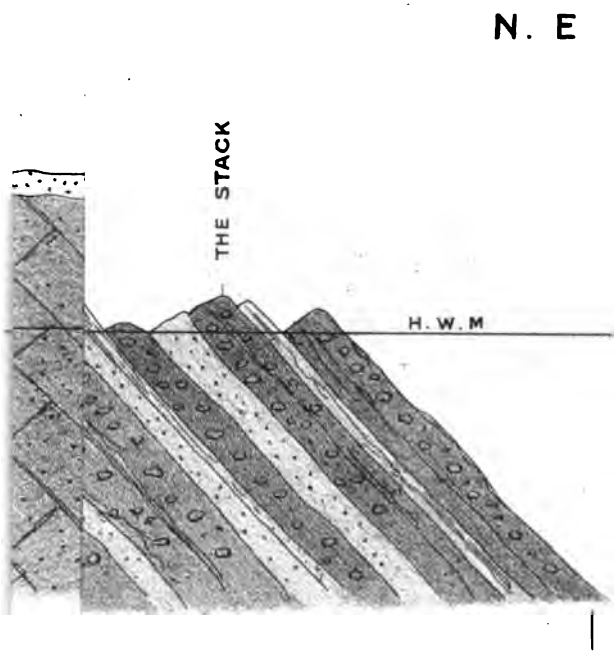
Trans. Min. Geol. Soc. Lond. XXI. Vol. XXII
To illustrate Prof. Boyd Dawkins' Paper.



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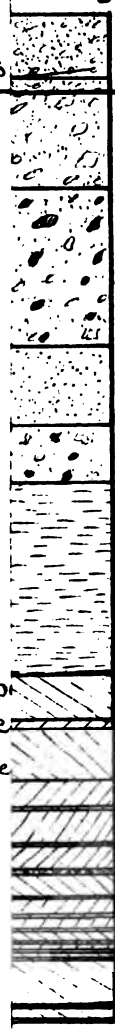
Trans. Man. Geo. Soc. Part XXI. Vol. XXII
to illustrate Prof. Boyd Dawkins' Paper.

SECTION III

UE POINT, BALLAWHANE

THE TRIASSIC SANDSTONE.



	THICKNESS OF STRATA ft	in	
Boulder Drift Series 167' 6"	16	0	Sand and Shingle
	29	0	Sandy Boulder Clay.
	41	0	Sandy Boulder Clay with fragments of Coal
	20	0	Sand
	15	0	Boulder Clay
	50	0	Silt
Carboniferous Limestone	11	6	Red Sandstone
	2	3	Red Sandstone and Marl
	12	9	Red Sandstone
	7	6	Fine red Micaceous Sandstone
	8	8	Fine Grey Sandstone false bedded.
	8	4	Coarse Red Sandstone
	6	2	Mottled Sandstone
	2	0	Red Micaceous Sandstone
	5	0	Mottled Sandstone
	3	6	Red do
	2	2	Grey do
	2	10	Red do
	1	8	Coarse Red Sandstone with partings of Marl
	2	2	Grey do
	1	6	Red do mottled
	1	8	Red do
	2	7	Red Red Marl Sandstone
			Red and Grey laminated Sandstone
	11	9	Red Sandstone
	2	3	Red Marl with fine Grey do
		11	Red do do Red do
			Red Sandstone - Micaceous - Ripple Marked.

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that north-eastern Ireland, the northern part of the Isle of Man, and the area of the Lake district including the Vale of Eden, were parts of the same Permian marine basin, in which, as it approached southern Lancashire, the waters gradually were more highly charged with mud, the calcareous element being conspicuous in the one, and being replaced in the other by thick accumulations of marl.

5. *The Drift-covered Northern District.*

The Ordovicean slates, quartzites, and conglomerates, and the associated volcanic rocks of the *massif* of the island, gradually pass underneath the sand, shingle, and clay of the Boulder Clay series in going northwards along the coast, towards Kirk Michael, until they disappear altogether from the cliffs and the shore. They stand up conspicuously along the ancient shore line extending from Kirk Michael to Ballaugh, Sulby, and Ramsey, commanding the low, sandy, and marshy region which forms the northern portion of the island, and contrasts in its flatness with the lofty rolling Ordovicean hills behind, culminating in Sartfell, Snaefell, and North Barule. This physical contrast is obviously the result of a difference in the physical character of the rocks in the two districts. The problem as to what rocks underlie the glacial strata, which has occupied my mind for many years, is now partially solved by the three borings which have been made under my advice by Messrs. Craine in 1891-4, in search of the Coal Measures of the Whitehaven Field, at the Point of Ayre, at Blue Point, and at Lhen Moar. To Mr. John Todd, the engineer in charge, I am indebted for the following sections:—

A. *The Carboniferous Limestone.*

The boring at Lhen Moar at the point indicated on the map revealed the existence of the Carboniferous Limestone in the north of the Island.

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SECTION II.—THE CARBONIFEROUS LIMESTONE AT LHEN MOAR.

	Below Surface. Ft.	in.		Thickness. Ft.	in.
Boulder Drift Series	—		....	167	6
Sand and Shingle	0	0	....	12	0
Silt	12	0	....	6	0
Grey Sand	18	0	....	48	0
Brown Sand	66	0	....	26	0
Sand and Shingle	92	0	...	18	0
Shingle	110	0	....	8	0
Grey Sand	118	0	....	9	0
Shingle	127	0	....	40	0
Silt	167	0	....	0	6
Carboniferous Limestone	167	6	....	66	0
Total depth	233	6		—	

The diamond drill was used when the Carboniferous Limestone was reached.

The Carboniferous Limestone dips at a high angle of about 40°, and is similar in character to that of the south of the Island at Castletown. Its discovery in this spot some 150 feet below ordnance datum renders it very likely that the *massif* of the Island stands out from a setting of limestone now mostly submerged and coming to the surface only in the south.

B. *The Triassic Sandstone.*

The next borehole at Blue Point, about 4,050 feet to the north-east of that at Lhen Moar, and beginning also but a few feet above H.W.M., revealed the presence of Red Sandstone beneath the drift.

SECTION III.—THE TRIASSIC SANDSTONE AT BLUE POINT, BALLAWHANE.

	Below Surface. Ft.	in.		Thickness. Ft.	in.
Boulder Drift	—		...	171	0
Sand and Shingle	0	0	....	16	0
Sandy Boulder Clay	16	0	....	29	0

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	Below Surface. Ft.	in.		Thickness. Ft.	in.
Sandy Boulder Clay, with fragments of Coal	45	0	....	41	0
Sand	86	0	....	20	0
Boulder Clay, with fragments of Coal ..	106	0	....	15	0
Silt	121	0	....	50	0
Triassic Sandstone	171	0	....	60	8
Red Sandstone	171	0	....	11	6
Red Sandstone and Marl	182	6	....	2	3
Red Sandstone	184	9	....	12	9
Fine Red Micaceous Sandstone	197	6	....	7	6
Fine Grey Sandstone, false bedded ..	205	0	....	0	8
Coarse Red Sandstone	205	8	....	8	4
Mottled Sandstone	214	0	....	0	2
Red Micaceous Sandstone	214	2	....	6	0
Mottled Sandstone	220	2	....	2	0
Red Sandstone	222	2	....	5	6
Grey Sandstone..	227	8	....	0	2
Red Sandstone	227	10	....	3	10
Grey Sandstone..	231	8	....	0	8
Coarse Red Sandstone, with parting of Marl	232	4	....	2	7
Grey Sandstone..	234	11	....	0	3
Red Sandstone	235	2	....	2	6
Red Mottled Sandstone	237	8	....	0	6
Red Mottled Sandstone, with partings of Marl	238	2	....	1	9
Fine Red Marl, with spangles of mica ..	239	11	....	0	9
Reddish Grey Sandstone	240	8	....	1	2
Red and Grey laminated Sandstone ..	241	10	....	0	7
Red Sandstone	242	5	....	11	9
Red Marl, with fine Grey Sandstone ..	254	2	....	0	3
Red Marl, with fine Red Sandstone	254	5	....	2	9
Red Sandstone micaceous, ripple-marked	257	2	....	0	11
Total depth, February 22nd, 1894..	258	1			

The diamond drill was used for the lower part of the boring from 197 feet 6 inches to the bottom.

The Red Sandstone in this section differs from the Permian Rot-todt-liegende of Peel in the absence of pebbles and in

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its finer grain. In my opinion it is identical with the St. Bees Sandstone or lowest member of the Triassic Formation, in the district of the Lakes.

C. *The Saliferous Marls of the Point of Ayre.*

This conclusion is greatly strengthened by the discovery in the third boring at the Point of Ayre, to the east of the Lighthouse, of the Triassic Marls with salt, at a distance of a little under five miles from Blue Point.

SECTION IV.—THE SALIFEROUS MARLS AT THE POINT OF AYRE.

	Below Surface. Ft.	in.		Thickness. Ft.	in.
Boulder Drift Series	—		....	298	0
Shingle	0	0	....	23	0
Sandy Shingle	23	0	....	70	0
Running Sand	93	0	....	6	0
Clay	99	0	....	3	0
Sandy Gravel	102	0	....	2	0
Clay	104	0	....	6	0
Hard Sand	110	0	...	9	0
Clay	119	0	....	8	0
Hard Sandy Clay	127	0	....	20	0
Clay	147	0	....	3	0
Sand	150	0	....	4	0
Clay	154	0	....	4	0
Sand	158	0	....	8	0
Soft Sandy Clay	166	0	....	2	0
Hard Brown Clay	168	0	....	10	0
Gravel	178	0	....	2	0
Sandy Boulder Clay, with Stones	180	0	....	4	0
Sand	184	0	....	3	0
Sand, with Stones	187	0	...	6	0
Hard Sand	193	0	....	6	0
Silt	199	0	....	17	0
Sand	216	0	....	2	0
Hard Sand	218	0	....	10	0
Sand	228	0	....	69	0
Gravel	297	0	....	1	0

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	Below Surface. Ft.	in.		Thickness. Ft.	in.
Triassic Marls	298	0	....	382	0
Mottled Brown Grey Marl	298	0	....	54	0
Mottled Brown and Grey Marl, with Gypsum	352	0	....	101	0
Light Blue Marlstone	453	0	....	3	2
Brown and Blue Marls	456	2	....	44	9
Light Blue Marlstone, with Salt	500	11	....	11	0
Brown and Grey Marls, with Salt	511	11	....	19	9
Brown Marl, with Veins of Gypsum ..	531	8	....	1	6
Light Blue Marlstone	533	2	....	3	9
Brown Marl, with Veins of Gypsum ..	536	11	....	1	0
Brown Marl and Blue Marlstone	537	11	....	26	11
Marl, with Salt	564	10	....	0	10
Blue Marlstone	565	8	....	1	6
Brown Marl	567	2	....	3	2
Brown Marl, with Blue Marlstone, containing Veins of Gypsum and Salt ..	570	4	....	45	1
Brine Run	615	5	....	2	6
Blue Marlstone	617	11	....	8	1
Grey Marlstone, with Marls	626	0	....	9	2
Salt	635	2	....	20	0
Mixed Salt	655	2	....	0	8
Salt	655	10	....	3	4
Grey Marlstone, with Salt	659	2	....	4	0
Salt	663	2	....	9	6
Brown Marl	672	8	....	7	4
Total	680	0		—	

The diamond drill was used from a depth of 452 feet to the bottom. The total thickness of the salt-beds amounts to 33 feet 6 inches, and the bore-hole happened also to intersect a brine-run, 2 feet 6 inches in depth. The surface as in the other borings is but a few feet above high water mark.

6. *Comparison with other Saltfields.*

If this section be compared with that published by Mr. Dickinson of the Saliferous Marls of Duncrue, near Carrickfergus, it will be found to be practically identical.

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SECTION OF SALIFEROUS MARLS AT DUNCRUE, NEAR CARRICKFERGUS.

	Below Surface. ft.	in.		Thickness. ft.	in.
Soil*	0	0	....	1	6
Boulder Drift	1	6	....	61	6
Brown and a little Blue Marl with Gypsum	63	0	....	672	0
Rock Salt	735	0	....	15	0
Brown Marl and Marlstone	750	0	....	6	0
Rock Salt	756	0	....	93	0
Brown Marl and Marlstone	849	0	....	1	0
Rock Salt	850	0	....	45	0
Brown Marl and Marlstone with Rock Salt	895	0	....	5	0
Total depth	900	0			

The same series of salt-bearing marls is also worked at Barrow-in-Furness, and at Preesall, near Fleetwood.

SECTION OF SALIFEROUS MARLS AT PREESALL, LANCASHIRE.

	Below Surface. Ft.	in.		Thickness. Ft.	in.
Soil†	0	0	....	1	0
Sand and Gravel	1	0	....	1	0
Soft Blue Clay, with Sand	2	0	....	44	5
Running Sand	46	5	....	2	0
Hard Strong Clay	48	5	....	24	0
Blue and Yellow Stone	72	5	...	5	8
Soft Red Shale, with blue and white partings	78	1	....	53	3
Blue Shale, with Gypsum	131	4	....	25	0
Red Shale	156	4	....	44	4
Grey Shale	200	8	....	5	0
Brown Shale	205	8	....	35	0
Soft Grey Shale, with Gypsum	240	8	....	17	10
Rock Salt and Shale	258	6	....	19	6
Rock Salt, with partings	278	0	....	6	0

* Dickinson, *Report*, 1881.

† From surface to 525 feet, Dickinson, Report, 1881, p. 58. The rest from private information.

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	Below Surface. Ft.	in.	Thickness. Ft.	in.
Rock Salt, with Red Shale	284	0	18	0
Hard Rock Salt	302	0	19	0
Hard Rock Salt	321	0	14	9
Hard Rock Salt and Shale	335	9	1	4
Rock Salt	337	1	5	6
Grey Shale	342	7	2	0
Red Shale	344	7	2	0
Rock Salt, with grey partings	346	7	17	0
Grey and Red Shale and Salt	363	7	5	0
Hard Rock Salt	368	7	12	11
Rock Salt and Shale	381	6	13	10
Hard Rock Salt	395	4	6	1
Rock Salt and Red Shale	401	5	4	3
Rock Salt	405	8	9	9
Rock Salt, with grey partings	415	5	9	7
Red and Grey Shale, with Salt	425	0	1	8
Rock Salt and Red and Grey Shale	426	8	11	4
Rock Salt	438	0	10	6
Rock Salt, Red and Blue Shales	448	6	8	4
Rock Salt	456	10	19	0
Inferior Rock Salt	475	10	43	2
Good Rock Salt	519	0	29	0
Superior Rock Salt	548	0	4	6
Good average Rock Salt	552	6	30	6
Very good Rock Salt	583	0	13	0
Inferior Rock Salt	596	0	4	6
Fair quality Rock Salt	600	6	3	0
Red Shale	603	6	19	6
Total depth	623	0		

The salt beds in each of the above cited cases are variable in thickness, and those in the Isle of Man are thinner than in the above cases. It must, however, be remembered that the Manx boring has not been put down to a sufficient depth to test the true thickness of the saltfield.

The discovery is of great theoretical importance, because it links on the deposit at Barrow with that of Carrickfergus,

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and shows that the Irish Sea was an area in which the salt-bearing Triassic Marls were deposited. It points towards the truth of Mr. Dickinson's suggestion that the Cheshire saltfield was formerly continuous with that of Ireland. These marls have since been broken up, faulted, and denuded away in many places. It is an open question how far those of the Isle of Man are now continuous under the sea eastwards to Barrow and Fleetwood, and to the north-west in tho direction of Carrickfergus.

7. *The Boulder Drift.*

A thick mantle of Boulder gravels, sands, and clays covers the solid rocks in the northern part of the Island, and forms the great flat north of Ramsay, and Sulby and Ballaugh, which rises into a range of hills in Bride and to the north of Andreas 150 feet high. It forms the line of cliffs which are so rapidly being carried away by the sea between Kirk Michael and Sulby, and of those between Ramsay and Crimstal. It is 298 feet thick at the Point of Ayre, 171 feet at Ballawhane, and 167 feet 6 inches at Lhen Moar. To get its true thickness the height of the hills above mentioned must be added, which will make it no less than about 450 feet. It is deposited on a floor of solid rock, rapidly descending from the south-west to the north-east to a depth of about 288 feet below H.W.M. at the Point of Ayre. From this great mass of drift one tongue sweeps southwards from Ramsay in the direction of Laxey, and another between Peel and Kirk Michael, southwards past St. John's. There are also minor prolongations in Glen Auldyn, Sulby, and Ballaugh Glen. The numerous local patches in the higher grounds in the middle of the Island show that it extended high up in the hills. In the south it forms a continuous sheet in Arbory, Malew, and Santon, rising to a height of

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above 600 feet. It is evidently glacial detritus derived from the melting of ice in the shape of bergs in some and of glaciers in other places. In the north of the Island at all events the icebergs probably did much of the work. The movement of the ice was from north to south, as is proved by the transported blocks derived from Scotland and the Lake District.

8. *The Rocks underneath the Drift.*

The Boulder-drift sand, gravel, and clay, ends abruptly against an old line of cliff, ranging from Ramsay to Kirk-Michael, and conceals a sea-floor, deepening to the north-east. In all probability it is composed of softer rocks than the Skiddaw slates of the *massif*, which have been faulted down, as in the case of the Permians of Peel, and of the Carboniferous Limestones of the south. Their precise nature can only be ascertained by experimental borings, similar to those described in this paper. It must further be noted that the distribution of the Carboniferous Limestone, Triassic Sandstone, and Saliferous Marls shown in the map, merely represents a probable range.

9. *General Conclusion.*

It now remains in conclusion to compare the rocks in the north of the Isle of Man with those of England. The clay-slates, phyllites, and quartzites are practically identical with the Skiddaw series of the Lake country. The Carboniferous Limestone and the Permians are related to the Skiddaw series in both areas in the same way, resting unconformably upon it, as for example on the flanks of Black Combe (Geological Survey, Map 98 S.W.). The Triassic Sandstone is probably of the same age as that of Aldingham and Barrow, which clearly overlies the Magnesian Limestone (Sheet 91, N.W.), and passes underneath the Saliferous Marls of Barrow. The sequence of the rocks in the Island

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is exactly that of the Lake District, and the geology of the one is to be read by the light of the other. We may also conclude from this identity of structure between the areas of Barrow and Black Combe on the one hand, and of the north of the Island on the other, that the Coal Measures of Whitehaven do not range so far south as the Isle of Man. If they do occur the only spot where they can be hoped for is in the extreme north of the Island, to the north of the Carboniferous Limestone of Section II. The gallant attempt to prove them by Messrs. Craine has resulted in an important addition to our knowledge, not merely of the geology of the Island, but of the range of the salt-bearing marls. It will probably result in the establishment of the salt industry, and in an important addition to the resources of the Island, which has been so closely connected with Lancashire for many centuries through the Earls of Derby, and in later times by the charms which attract an ever increasing crowd of our working men.

Mr. Ward moved that the best thanks of the meeting be given to Professor Dawkins for his valuable communication.

Mr. Joseph Dickinson, in seconding the motion, said he did not gather from the section the depth at which the salt had been reached. What was the relative position with regard to the sea level?

Professor Dawkins: The first layer of impure salt was struck at about, in round figures, 500 feet below sea level.

Mr. Dickinson: Then it would be interesting to know how it was that, in approaching this salt, the boring rod suddenly dropped 2 feet 6 inches, apparently through brine. What would cause that brine there? Where would be the outlet for the water flowing over the rock salt? Another

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question arises with regard to the Boulder clay, which the Professor tells us is 298 feet thick. That must have been a formation of marl of some kind, and the question is whether it can have been disturbed by the water of the sea, and some of the boulders which are in it have got access during the disturbance. The thickness of the deposit is enormous. I cannot call to mind a parallel case; but in the Lower Red Sandstone, which lies underneath the Permian marls at Pendleton, there is an enormous thickness of sand—I should think probably as great a thickness as this drift in the Isle of Man. There is no doubt that the sand represents the lower or Permian Sandstone, and it may be the enormous thickness of drift represents some formation. These may be points of interest apart from the mere fact of the discovery. I think, however, we shall need to study the subject a little more before we can discuss what the Professor has so admirably described.

The PRESIDENT: I think Professor Boyd Dawkins is to be congratulated on being connected so intimately with the development of our mineral resources. We all know, from the papers he has read to us, how important a part he has taken in the prospecting for coal near Dover, and now we learn that he has been connected with an effort to find coal in the Isle of Man, which, however, has resulted in the discovery of salt. It seems to me there is need in the Isle of Man of some mineral resources to attract population. At present the Island is dependent entirely on the tourist traffic for its prosperity. It is to me a point of great interest that salt should have been found in the northern part of the Island. There cannot be a doubt that originally there was a great saltfield extending from Fleetwood to the northern part of Ireland; and the deposits at Barrow, Fleetwood, and the Isle of Man are simply outlines of that great field. I have much pleasure in putting the vote of thanks to the

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meeting, and I am sure the paper will be a most valuable addition to our Transactions.

The vote of thanks was passed unanimously.

A Member: Can Professor Dawkins tell us what was the strength of the brine found in the Isle of Man?

Professor Dawkins: I am afraid I have no accurate information on that point.

Mr. Hobson (a Visitor), after remarking that they ought to be very glad that the important paper by Professor Dawkins had been communicated to the Manchester Geological Society, and that all the good things did not go to London, said: There is one point on which I would like to ask for information, and if it had occurred to me before I should have asked the Professor privately. He has described this great thickness of Permian rocks—1,350 feet—in the neighbourhood of Peel; it is an enormous thickness to occur; and then, if we are to trust these borings, at any rate the sequence of the rocks, in the northern part of the Island, we do not find the carboniferous rocks resting on the Permian limestone at all. We have, therefore, in a distance of twelve miles 1,350 feet of Permian rocks (upon what they rest is unknown), and in the other place we have immediately resting upon the carboniferous limestone triassic rocks. There is, of course, no impossibility in this; but it is an extraordinary change, because such an enormous thickness of Permian rocks cannot have been purely local, at any rate, it is not very likely. We can only suppose that it was towards a very abrupt boundary of considerable depth, where the Permian was deposited, and that the rest was raised above the sea at that time, or else that the Permian rocks, this enormous thickness, had been denuded away before the Triassic rocks were deposited.

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Mr. DICKINSON said it was a mistake to put all their discoveries of salt down as a result of searching for coal. The Middlesborough discovery was made in the course of a search for water.

Mr. WARD pointed out that in the Carrickfergus beds the salt lay in peculiar pot holes, and not in a continuous bed. This, he thought, militated against the idea of there having been one extensive salt field extending from England over the area of the Irish sea. When in America (Mr. Ward went on to say) I went over an extensive district where salt production was carried on, and I found salt extending pretty regularly from one place to another, the dip, as appeared from the borings, being uniformly from north to south. They spoke of it as one field. At Fleetwood the salt deposit occurs in a ravine; it is extremely deep in one place, whilst a little distance away there is no salt at all. This shows that between Fleetwood and Barrow the rock salt is not continuous. The discovery in the Isle of Man is interesting. It does lie in a line between these various deposits, and may at one time have formed part of one great marl field. The thickness of the bed will, I think, debar it from being worked as a mine. In Cheshire it is only in a bed 30 or 40 yards thick, where they can get about five yards of rock salt that is worth working at all. The probability is, in all deposits of this character you will find more marl than salt. Brine is far more valuable than rock salt, commercially; but the great drawback to the profitable manufacture of salt in the Isle of Man is the absence of coal. The coal required in the manufacture would have to be imported. It is interesting to learn that in America, all round the area of the great lakes, rock salt is being found.

Professor DAWKINS: May I ask what age are those?

Mr. WARD: They are old—much older than our Trias. It is very interesting that the deposits which have been

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found should be connected with these large lakes and lie around them. Beds of salt are found in all sorts of places. Since I returned to England a number more have been discovered. They are none of them, however, very extensive. Salt has been found of late to an enormous extent in all parts of the world. The Isle of Man is the last place from which it has been reported, and the discovery there is very interesting.

Mr. Stirrup: We are very deeply indebted to Professor Dawkins for the paper he has brought before us to-day, because it conveys a mass of information which will be valuable to geologists, and also to those who have been prospecting for economical purposes. I feel also that the Manchester Geological Society is to be congratulated on having this paper brought before it, as I know attempts have been made to get at the statistics of these borings for the purpose of bringing them before other societies. We have, however, had the benefit of having this information brought *before us*, and that is something we may congratulate ourselves upon, and for which we have to thank Professor Dawkins more particularly. I am afraid the object for which these borings were undertaken has not been successful. It does not appear to me that there is much chance of finding the coal that was hoped for. If coal ever existed there, it seems, from the map before us, as if it had been entirely swept away at some previous geological epoch. The fact which Mr. Hobson mentioned of the thickness of the Permian rocks in the neighbourhood of Peel and their absence further north is certainly very remarkable. But I take it the Isle of Man has been a centre of great volcanic disturbance. This is proved by the occurrence of volcanic rocks in the south of the island, and the penetration among the slates and phyllites of volcanic matter. The most interesting, or one

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of the most interesting facts, to me, is the idea it gives us of the ancient geography during those very early periods of the earth's history. We may be tolerably certain that land was once continuous all across what is now the Irish Sea. The beds of salt at Carrickfergus, and those at Barrow and Fleetwood, were also, no doubt, partly continuous with the recently discovered deposits of the Isle of Man; but that the salt beds were co-extensive with the land is more than we are prepared to say.

Mr. Tonge: I should like to add a word of thanks to Professor Dawkins. The President said just now that the Professor ought to be congratulated upon being so intimately connected with various recent discoveries. Next to that I think this Society also is to be congratulated upon having been the first, generally speaking, to have had those discoveries laid before it.

Mr. Watts: There is one matter I would like a little information upon. That is the circumstance referred to by Mr. Dickinson of the boring rod having dropped 2 feet 6 inches. It seems to me a vertical joint may have existed there, or a circulation of water from a higher level than the sea may possibly have taken place. We know that water does circulate for long distances in rock, and if it be fed from a higher point it must descend and come out somewhere, and probably a circulation of water in the underground rocks has been the means of the boring rod dropping the 2 feet 6 inches. A great cavity could not exist for any great distance on account of the mass of superincumbent strata, 600 feet thick. Perhaps Professor Dawkins will be able to give a little more information on that point.

Professor Boyd Dawkins said: I think myself very fortunate in having had this reception this afternoon. Replying to the questions which have been asked, I will

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apply myself, in the first place, to that with regard to the brine run. I am afraid I cannot give you any information regarding it beyond the bare fact that the boring tool dropped down to that extent, and that a considerable quantity of brine made its appearance immediately afterwards; and, looking at the condition of some of these partially dissolved lumps of salt, now on the table, I think we have evidence of salt in solution at certain points in the boring. The brine did occur in a cavity at a depth of 615 feet. It would prevent the crushing in of the cavity suggested by Mr. Watts. It makes an exceedingly good and solid foundation unless there is some outlet for it. You may build with impunity on a layer of rock which is supported by brine.

Mr. Ward: You frequently have the experience in the salt districts of the boring tool dropping down.

Professor Boyd Dawkins: Another point was raised by Mr. Hobson. It is undoubtedly difficult to account for these rocks not appearing somewhere along that line. They ought to appear; but as a matter of fact we all know how extremely irregular the Permian rocks are in England. Near St. Helens you find Triassic sandstone lying or resting under the Coal Measures, while a little way off you find it on the Permian red marls and sandstones. I do not know any rock so irregular in its distribution as the Permian. At the same time I would not say that it does not exist anywhere under this northern flat. So far as relates to these borings, there is no evidence. At Barrow the rocks are related to each other as here, but with this difference, that between the Carboniferous Limestone and the Triassic sandstone in that area we have the Magnesian Limestone. With regard to the question of the relation to Fleetwood, I think there is no point of difference between myself and my friend, Mr. Ward. I did not for

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one moment maintain that the beds of salt at Fleetwood are now continuous under the Channel all the way to Ireland; but I do think it probable that the marls containing these layers of salt, if not now continuous, were formerly so. On that point we are agreed. With regard to Mr. Ward's remark as to value, I would merely say that Mr. Ward is not only a very able member of this Society, but also a prominent member of the Salt Union. I look forward to the time when the Salt Union, out of sheer self-defence, may perhaps be obliged to buy up the Manx saltfield. I ought to add that Mr. Craine, one of the gentlemen to whom we owe these discoveries, is here, and he tells me that the brine rises within 70 feet of the surface.

Mr. Craine: That is proved by the Engineer on the spot, beyond all doubt.

Mr. Gerrard: With regard to the continuity of the rock salt beds, it is proved by the numerous holes, and shafts that have been put down in the Carrickfergus district, that you quite as often fail to find rock salt as you succeed. That is beyond all manner of doubt.

NOTES ON PLANT AND FISH REMAINS FROM THE JARROW COLLIERY, Co. KILKENNY.

By Herbert Bolton, F.R.S.E., Assistant Keeper, Manchester Museum, Owens College.

By the kindness of your President, W. Saint, Esq., I have been enabled to examine an interesting series of specimens from the Jarrow Colliery, Co. Kilkenny, Ireland.

These specimens, which are now laid before you, consist of plant and fish remains. The latter are represented by two fin spines, and by impressions of the greater part of the body of a fish upon three blocks of anthracite. The plant remains are chiefly lepidodendroid. The modes of occur-

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renee of these fossils is peculiar. They are all found in the Jarrow coal. The plant fossils, I am informed, are found in the lower layers, whilst the fish remains occur throughout the coal.

Introduction.

Whilst the Irish coalfields cannot compare in interest with the much larger deposits of England, yet the Jarrow coal has received the close attention of several eminent workers.

This coal has been taken by the Irish Geological Survey as the basement seam of the Middle Coal Measures of the Leinster coalfield, an elevated tableland occupying portions of Kilkenny, Queen's Co., and Co. Carlow.

The measures are basin-shaped, and consist of dark shales, flagstones, and coals, all of which are anthracitic.

The shales contain such fossils as Aviculopecten, Euomphalus, Bellerophon, and Goniatites, an assemblage sufficiently characteristic of their estuarine origin. The coals, and the beds in close association with them, have yielded the ordinary plant fossils of the Coal Measures; the spines of fishes, whole fishes, and an unique series of amphibian remains.

These latter were obtained in the Jarrow Colliery from the slate in immediate contact with the upper surface of the coal. Professor Huxley, who described these remains in a paper read before the Royal Irish Academy,* recognised seven genera and species.

The fish remains from the coal were recognised by the officers of the Survey as belonging to Gyracanthus, Megalicthys, and Campylopleuron.† More lately‡ Dr. Traquair

* Prof. Huxley, Trans. Roy. Irish Acad., Vol. xxiv., Science, 1867.

† Explanatory Memoir on the Geology of the Leinster Coalfields. Geol. Survey of Ireland, p. 25.

‡ Myriolepis Hibernia. Dr. Traquair, Geol. Mag., Dec. iii., Vol. x., p. 54, pl. iii.

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has described a new species of the genus Myriolepis, to which he has given the name of "Hibernia."

It will be seen from the list of fossils that the Jarrow coal is of considerable interest. When we turn to the Survey Memoirs* still more interest is engendered by the detailed description of several collieries where the coal is found to rest upon what is called a black slate, a seat rock being absent.

Mr. G. H. Kinahan,† describing the section of the Rock Colliery, says: "This is a most remarkable section, as there is no fire-clay under the coal, and grits take the place of most of the shales over it." The coal in this description is called the "No. II." Coal, but, on page 44 of the "Explanation," is identified with the Jarrow Coal.

A number of sections of various collieries are given, showing that the seam is an extremely variable one, and that a fire-clay seating is not wholly absent.

At the Rock Colliery the seam is 2 feet 8 inches thick, and is underlaid by a black shale 2 feet 6 inches in thickness. At Coolbaun, to the south-east, the seam thins down to 6½ inches, and has a fire-clay of relatively enormous thickness, namely, 7 feet 8 inches. At Gazabo Church "No. II." Coal is 3 inches thick and has a 3-inch fire-clay. A little to the south of Massford the coal increases to 3 feet 9 inches, and possesses a fire-clay 2 feet thick.

Another section taken 250 yards to the west of the last showed that the coal (described as coal, kelve, and mixture) had increased to 16 feet.

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* Explanation of Sheet 137, Geol. Surv. of Ireland, Dublin, 1859; Explanatory Memoir on the Geology of the Leinster Coalfields, by E. T. Hardman, F.C.S., and W. H. Bailey, F.G.S., Dublin, 1881.

† Explanation of Sheet 137, p. 40.

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In two sections only 450 yards apart the coal increased from 3 inches with a 3-inch fire-clay to 2 feet 6 inches with a 2 feet 6 inch fire-clay. At one of the Jarrow Collieries the coal is given as 5 feet 5 inches thick, with two partings.

At page 45 of the "Explanation" Mr. Kinahan sums up his researches upon the Jarrow Coal with the following statement: "From these sections and evidence it is seen that here is a great cake of coal, which thins out as we proceed in every direction but the west from Jarrow pit. At the west no trial has been made."

In the Memoir issued in 1881 the Jarrow Coal is taken as the basis of the Middle Coal Measures, and is renamed "No. IV."

An additional note is given to Kinahan's description of the seam at Rock Colliery, the roof being described as a hard brittle slate, and the floor as a hard black stone. The average thickness of the seam is put at 18 inches, but varying between 13 inches and 5 feet.

At the old and new Jarrow Collieries the seam was found to occasionally reach 10 feet 8½ inches, and 16 feet, but the average thickness is between 3 feet 6 inches and 4 feet.

Having now learned something of the physical features of the seam, we will examine the fossils derived from it which are laid before you.

Description of Fossils.

The specimens are all embedded in coal from the Jarrow seam. It will be noticed that the coal differs in character in various portions of the seam. At the bottom it is a dark smutty anthracite, much jointed, and separating easily into thin layers about one quarter of an inch in thickness. A large amount of sulphur is present as a grey film upon the cleavage faces. The bedding planes have not unfrequently

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a beautiful semimetallic polish, due to the presence of a thin carbonaceous film, which is not unlike graphite.*

Spread over the surface of the bedding planes in the lower portion of the coal are a series of flattened pyritised casts of lepidodendroid branches. The feature which most readily strikes the eye is the low relief of the casts on certain of the slabs, and the occurrence of corresponding depressions on others.

I am informed that the surfaces on which the specimens are in low relief are the *lower* surfaces, the slabs being therefore now upside down. The depressions are upon the true upper surfaces.

Before we discuss either the circumstances under which these interesting fossils accumulated or the conditions which determined their preservation it is necessary that they be examined in detail. For this purpose I have indicated them by Roman numerals.

No. I. is a fairly large slab, consisting of a layer of dark slate ("kelve" of the Irish mines?) 1½ inches thick, closely united with a 2-inch layer of anthracite. The line of junction is sharp and clear. The slate is somewhat graphitic in appearance, and laminated, but not readily broken up or detached from the coal. It possesses a slight cleavage similar to that of the coal.

Here and there it is marked by irregular areas of parallel raised lines which so much resemble the venation of Cordaites, whilst they differ from anything else in the Coal Measures, that we assume they belong to disintegrated leaves of that genus.

* The conversion of anthracite in graphite is recorded by several observers. The best-known case is that at Craigman, New Cumnock, Scotland, which was described by J. Nicol in 1844 ("Guide to the Geology of Scotland," p. 95), and is alluded to by Giekie ("Text Book of Geology," p. 146), Solms-Lanbach ("Fossil Botany," p. 13), and Boué ("Essai Geologique sur l'Ecosse," p. 470).

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The anthracitic layer bears a few casts of the woody axes of lepidodendroid branches.

The largest fragment crosses the middle of the slab and still shows a series of slightly-raised elongated tubercles of Halonia. One point of interest in the specimen is the mode of branching which it exhibits. Whilst lepidodendra usually divide into two equal-sized branches, in this case one branch is less than half the size of the other. The larger branch carries a well-defined "Halonia" tubercle at its extremity. Lying underneath are three smaller similar branches which might easily be mistaken for stigmaria, but their small size, and the impression of a few tubercles are evidence to the contrary. I know of no stigmaria having been described or noted in any way which might be compared with these, whilst the close resemblance which Halonia sometimes has to Stigmaria has been noted by Solms-Laubach ("Fossil Botany," p. 214).

Whatever the condition of these branches when deposited they are now almost wholly composed of iron pyrites.

No. II. slab is an oblong block bearing the impress of two forked branches of Halonia. A few smaller branches are present with an even stronger resemblance to Stigmaria than those of the first slab.

Apart altogether from the presence of tubercles, and the resemblance which may obtain at times between Halonia and Stigmaria, the question of thickness is no mean guide, Stigmarian roots are remarkable for their uniform diameter over great distances, and for the retention of this thickness close up to the growing point of the rhizone or root, whichever these structures may be. Also we believe that by means of the series of specimens now before you, the gradual passage from a clear lepidodendroid stem to a stigmarian-like Halonia can be demonstrated.

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Running across this slab is an irregular fissure which has been filled in by a white crystal mineral. This very largely dissolves away with effervescence in hydrochloric acid, showing that it is chiefly calcite, but a crystalline residue is left which easily crumbles. It may possibly be selenite, the free sulphur in the coal having replaced the carbon to form a sulphide.

No. III. is a large slab which has been badly broken, but of considerable interest, since it shows very clearly the condition of the various layers at the time accumulation was taking place. The surface bears the impression of several branches. A study of these impressions shows that previous to the deposition of the upper layer with branches the lower layers had acquired considerable consistency, the upper crust becoming hardened. I have failed to note any signs of branches passing through it in a vertical direction.

When the upper layer was being deposited upon the lower, the branches, &c., in the former were pressed down by the weight of vegetable matter above them, upon the surface of the lower layer, but without actually breaking it. The surfaces of the lower layer merely took a mould or cast of the external surfaces of the branches, so that when separation of the layers took place they came away readily in the under surfaces of the upper layer, upon which they appear in low relief, leaving behind them a shallow depression, which is seen to be directly continuous on all sides with the surface of the bedding plane. A little calcite fills up an irregular fissure as in No. II.

Nos. IV. and V. are two slabs bearing branches in low relief as before, but much smaller, and studded with tubercles. The resemblance of these specimens to stigmaria is exceedingly close, and it was only after considerable examination and comparison that I could regard them as Halonia. The

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upper surface of No. IV. has several patches of "mother of coal."

No. VI. is a slab of anthracite with one large lepidodendroid branch a foot in length, which shows the leaf-scars as a series of lozenge-shaped pits. It is overlaid by several equal-sized halonoid branches, which are much flattened and twisted at their extremities, as if they had been split up for some distance along their length by crushing. Notwithstanding their crushed condition, the tubercles are quite distinguishable. A large quantity of what appears to be graphite is present.

No. VII. is but a small mass of anthracite 6 inches square, bearing a small lepidodendroid branch having the shape of the letter Y. The branch is almost twice as broad as the halonia forms we have already considered. The surface is covered with small keel-like protuberances arranged in spirals. These are the leaf-trace markings of the supepidermal tissues of lepidodendron. In this case the whole of the bark has not been destroyed, but only the outer layers.

No. VIII. is a slab bearing a lepidodendroid branch of the type familiar to us from the Lancashire Coal Measures. Leaf-scars are present, and of the usual type. They are large, lozenge-shaped, and convex. Although leaf-scars are present, yet they are borne by the supepidermal tissues, and no coaly layer is present above them to indicate that the outermost layers of bark were still in place at the time of deposition.

No. IX. is a good specimen of a "knorria" cast of lepidodendron, about 6 inches square. In a knorria cast, as defined by Solms-Laubach, the ordinary lozenge-shaped leaf-scars of the surface layers, or the halonia tubercles of the deeper tissues are absent, the surface of the specimen being covered with a parallel series of elongated protuberances, which are rounded at their upper extremities, and

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run down the stem for some little distance. They are arranged in spiral fashion, and overlap one another from below upwards.

Nos. X. and XI. carry small halonoid branches of the kind we are now familiar with.

No. XII. is a mass of earthy iron pyrites and anthracite, carrying bifurcating branches of halonia. These show very satisfactorily that the halonia forms we have dealt with are but a condition of preservation of lepidodendron, for the face of these branches still retain the leaf-scars of lepidodendron in addition to prominent halonia tubercles.

No. XIII. is a beautiful fragment of the largest halonia in the collection. It is three inches broad, and lies upon a fragment of slate or "kelve." Most of the branches hitherto described have only had a diameter of 1¼ inches, and one only half an inch.

No. XIV. is a slab about 1 foot 9 inches long and 1 foot broad, with two halonoid branches and a small lepidodendron, the latter still showing the spirally-arranged leaf-trace impressions as a series of elongated pits. This slab, like No. III., indicates what in all probability was the mode of origin of the several layers of coal. The coal of this and, in fact, all the blocks has a dull, smutty appearance.

No. XV. Two fragments of halonoid branches of the ordinary type.

No. XVI. is a slab bearing halonoid branches, whose broken ends appear to have been frayed and splintered before deposition.

No. XVII. is a large slab 4 feet long by 2 feet wide, having several branches of the usual type in low relief. One of these branches has no trace of tubercles or leaf-scars, the exterior being smooth. It is much similar to No VII., and had the small keel-like remains of the leaf-trace scars

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in that specimen, to be destroyed by crushing, they would be indistinguishable. A small portion of the end of this specimen has been polished, and is seen to consist almost wholly of pyrites. The polished extremity shows that the branch is in reality a cylinder of wood, from which the central structures have been removed, the cylinder being afterwards crushed down upon itself, and the cavity obliterated.

No. XVIII. is a fragment of anthracite, showing an impression of small lepidodendroid leaf-scars of a rhomboidal shape.

No. XIX., a cast in ironstone of the leaf-scars of a lepidodendron. The leaf-scars are indicated by a set of deep pits filled with dark slate. When the latter is extracted each pit is seen to be a very good cast of a large leaf cushion. The cast is exactly similar to what we might obtain by means of wax from a stem, on which the leaf-scars are preserved in high relief. Before deposition took place the branch to which it was attached broke away, the deep pits left by the leaf-scars having afterwards filled with fine carbonaceous mud, which hardened into the slate we now see.

No. XX., a fragment of Stigmaria of the ordinary character and size, but much crushed. A comparison of this with any of those structures described as halonoid branches will serve to show the wide difference which exists between them. The Stigmaria cast is not associated with the coal, and I am unable to say how it occurred in relation to it.

Fish Remains.

The upper part of the Jarrow coal is a typical anthracite, massively bedded, having no definite cleavage, and destitute of slate bands. It is chiefly remarkable for its fish remains.

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One of the three specimens which are laid before you is of especial interest, as it adds something new to our knowledge of the species. The other are basal fragments of spines of Gyracanthus formosus.

The first specimen I have identified as Myriolepis Hibernica, a species first described a year and a half ago by Dr. Traquair. In the type specimen, which, by the kindness of the Keeper of the Manchester Museum is now laid before you, there is an impression only of the fish, minus the tail; the same occurs in the only other specimen hitherto known, which is in the Museum of the English Geological Survey, at Jermyn Street, London.

The present specimen of this species, which has been secured by your President, completes our knowledge of the shape of the fish. It consists of an impression of the hinder part of the body from the region of the anal fin, and includes an impression of almost the whole of the tail, together with a great part of it.

The additional information of Myriolepis Hibernica supplied by this specimen may be summarised by saying that the species possessed a powerful heterocercal tail of the Palæoniscoid type, and that the head bones were thin and covered by a ganoine layer of fine raised ridges. The opercular apparatus was continued underneath the jaw by a numerous series of branchiostegal rays.

Conclusion.

The facts which have been brought out in the previous part of this paper may be conveniently summarised before we discuss them.

The chief facts noted by the officers of the Irish Geological Survey and alluded to here are these :—

I. That in the case of the Jarrow coal at the Jarrow and Rock Collieries, no seat rock is present, its place being taken by a black slate.

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II. That in the immediate neighbourhood of this colliery, the thickness of the coal is exceedingly variable; ranging from a few inches up to ten and sixteen feet.

III. That the seam in this particular neighbourhood is in the form of a thick cake of coal thinning out on all sides except the west, which had not been proved.

IV. That at no great distance a fireclay comes in under the coal and increases in thickness up to seven feet, although in this latter case it only supports a three-inch seam.

From our description of the fossils you will also learn:—

V. That the plant remains occur in semi-relief along bedding planes in the lower part of the coal, whilst fish remains occur throughout.

VI. The lower layers of the seam consist of a smutty anthracite containing much sulphur, whilst the upper layer is pure, and of a typical anthracitic character.

VII. That the conditions of preservation are not those which usually obtain with coal plants, the fossils being in the condition of pyritised casts of the woody cylinders of the branches, instead of the more commonly occurring outer bark with leaf-scars.

This assemblage of facts is so singular that we venture to state at the outset that the ordinary hypothesis of coal growth is inapplicable.

The first fact with which we have to deal is of itself of great significance. There is an absence of fire-clay. This negatives an "in situ" theory for the particular area over which it occurs. The extreme variability of thickness is also a feature which calls for reflection. Also, Mr. Kinahan speaks of the seam as forming a cake thinning out in all directions except the west for Jarrow.

Where a seat-rock does occur away from Jarrow, as at Mazabo, the "in situ" theory may of course apply, but we

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find that whereas the fire-clay has a thickness of 7 feet, the overlying coal is but 6½ inches. This naturally raises a suspicion that a portion of the seam has been denuded off and transferred to those areas in which no seat-rock is present.

Whilst the absence of a fire-clay in one case, and the thinness of coal in the other, may be indicative of the circumstances under which accumulation has taken place, they do not furnish positive evidence.

When, however, we consider the plant and fish remains, we shall find that the conditions of preservation of the first, and inclusion in the coal of the second, point very clearly to a mode of origin.

The plant remains are all in the form of flattened casts, which are destitute of the outer surface markings, and in those conditions of fossilisation of lepidodendra which are known as "Knorria" and "Halonia."

Professor W. C. Williamson and others have shown that casts of this kind represent the outer layers of the woody axis and the deep supepidermal layers. Further, an examination of the polished ends of one of these branches shows that the pith has almost wholly disappeared, and that the fossil is really a crushed cylinder of wood.

When we notice that the conditions under which similar forms of Knorria and Halonia occur in the Coal Measures are remarkably constant, we assume that these conditions have determined the state of fossilisation.

In all other cases, as far as we are aware, these forms are found in the sandstones above or below the coal. In other words, Halonia and Knorria are found wholly in the water-formed rocks of the Coal Measure, and by virtue of their position must have been water-borne. We can best explain their present position by supposing them to be decaying twigs

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and branches which were lying upon the land surface, until swept off into streams, to be afterwards stranded upon sandbanks. Whilst lying upon the land surface the bark would be most exposed to destructive agencies, and we should, therefore, expect to find it destroyed or fragmentary. Once the branches had become stranded upon a sandbank, the rapid piling up of material over them prevented further disintegration, and they gradually passed over into the condition of fossils.

This argument has the support of Solms-Laubach, who (Foss. Bot., p. 21) states that the absence of an outer bark and the preservation of the supepidermal tissues has only occurred in water-drifted vegetation. From Solms-Laubach we also learn that in the ordinary mode of Lepidodendron fossilisation, the plants accumulating in a swamp or lagoon suffered decay by the *woody axis* rotting or floating out from the stems and branches, leaving an outer rind-like mass, which collaped upon itself into a flat ribbon, marked externally by the leaf-scars. Such fossils are the common ones of the coal.

The mere presence of these plant remains so well preserved and defined is suggestive. Had they been sunk in the waters of a lagoon, they would have become penetrated by rootlets and so broken up, and it is hardly conceivable that a thickness of coal could grow *in situ* above them, and the trunks and branches from which that coal is largely produced utterly effaced, whilst these still retained the form which they bore when first deposited.

The position in which they are found at the base of the seam, the condition of preservation, and the similarity of these fossils to the plant remains of water-formed rocks, added on to the absence of a seat rock or anything comparable to a soil, point wholly to the conclusion that this seam has not been formed *in situ*, but was water-borne.

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The presence of fish remains might reasonably be accounted for by supposing that sluggish streams made their way through lagoons, and were traversed by fish in search of food. This theory was put forward by the late J. W. Davis, of Halifax, in his monograph on Pleuracanthidæ.*

But it was also possible that by the breaking down of the side of a lagoon, or the bringing down of large quantities of peaty matter into the sea, that the fish were destroyed and their remains mingled with the vegetable *debris*.

After a careful consideration of the whole matter, I am disposed to put forward what I trust will be considered a reasonable hypothesis.

I take it that where a seat-rock occurs the usual theory of a lagoon or swamp origin will apply, but that in the area around Jarrow Colliery, where no seat-rock is present, we have to deal with a mass of vegetable material accumulated by water, as the result of a breach in the lagoon or swamp, through which was discharged, at successive times, a mingled mass of vegetable *debris*, made up of the bottom accumulations of the swamp and the twigs and branches which had been rotting on the surface.

But if we suppose such an event to have happened in the past, we should expect to find some evidence of similar occurrences to-day. This we do. Even in our own county, and in comparatively recent times, a moss or peat bog has risen, burst its boundaries, and overflowed a square mile of ground, and this, too, in the neighbourhood of a river and estuary whose waters were so contaminated that fish could not ascend the river. The case here alluded to is the history of Solway Moss in November, 1771, when, on a stormy night, an area estimated by one writer as 500 acres,

* Monagraph on the Pleuracanthidæ. By J. W. Davis, F.L.S., Sci. Trans. Roy. Dub. Soc., Vol. IV., ser. ii., p. 729.

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and by another as 5,000, was overwhelmed by a thick peaty mud which demolished houses, destroyed trees, and spread a covering of vegetable matter which in some places was 30 to 40 feet deep. In the Geologists' Association Proceedings,* where this occurrence is graphically described, it is further stated, "that the overflow found its way into the Esk, where its quantity was such as to annoy the fish, no salmon during that season venturing into the river."

Taking this case, and considering how its results would be increased if occurring in Coal Measure times, where there was a large extent of low-lying flat ground and an enormous development of a vegetation well calculated to choke the drainage, I think it will be evident that some such deposit of coal would be accumulated; a deposit variable in thickness, enclosing twigs and fish remains, and destitute of an under-clay.

NOTE ON MYRIOLEPIS HIBERNICA TRAQ.

By HERBERT BOLTON, F.R.S.E., Assistant Keeper, Manchester Museum, Owens College

A year and a half ago† Dr. Traquair founded the species of Myriolepis Hibernica upon two imperfect fishes from the Jarrow Colliery, Co. Kilkenny, Ireland.

The type specimen is in the Manchester Museum, Owens College; the other in the Museum of the Geological Survey, Jermyn Street, London.

A peculiar feature of both specimens is the loss of the tail, the bodies having been broken across immediately behind the anal fin. From this cause no description of the tail could be given.

* "Geology of North-West Cumberland," by T. V. Holmes, F.G.S., p. 91; *Proc. Geol. Assoc., Vol. XI., 1889.*

† Myriolepis Hibernica, Dr. Traquair, *Geol. Mag., Dec. III., Vol. X., p. 54, pl. III.*

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PLATE I.

Half natural size.

MYRIOLEPIS HIBERNICA.—Fore part of body, and portion of head.

Reg. No. L. 2647, Manchester Museum, Owens College.

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PLATE II.

Half natural size.

MYRIOLEPIS HIBERNICA.—Hinder portion of body, with anal fin, and greater part of tail and caudal fin.

Reg. No. 2648, Manchester Museum, Owens College.

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Through the kindness of W. Saint, Esq., your President, I have received for examination three blocks of anthracitic coal from the Jarrow Colliery, which bear the impress of fish remains.

A careful examination and comparison with the type-specimen has convinced me of their identity with Myriolepis Hibernica of Traquair.

The fish, or fishes, if the fragments are not parts of the the same individual, had a length of about 11 inches, and, since the tail is preserved, they help materially to complete the diagnosis of the species.

One of the blocks of anthracite shows the impression of the upper part of the head as far down as the upper boundary of the orbit, together with the anterior part of the body, as far back as the commencement of the single dorsal fin.

At the junction of the head with the body are a few hollow depressions, which curve gently downwards in the direction of the articular end of the lower jaw. These depressions we take to mark the position of the clavicular elements. The superficial ornament of the bones was impressed upon the coal, and has thus been preserved. It would appear that the clavicular elements were ornamented with a close series of delicate ridges, arranged concentrically from the upper extremity of the bones downwards. From the outline of the depressions, and the extent and arrangement of the ornament, we assume that the clavicular elements were long, narrow, and thin.

A small patch of similar ornament lies on the hinder region of the head, and possibly indicates the position of a post-temporal element.

No new feature can be determined in regard to the fore-part of the body, which shows the obliquely arranged rhombic scales and impressed skeletal elements described by

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Traquair. The second fragment of anthracite bears the impress of the hinder part of the body and the tail; the line of fracture passing upwards from the front edge of the anal fin to the fore part of the dorsal.

The tail itself, which is in beautiful preservation, forms a flat plate-like mass, half of which can be readily detached. It commences but a quarter-inch behind the termination of the anal fin, and is markedly heterocercal and Palæoniscoid.

From the root of the tail, the body pedicle contracts rapidly, and passes sharply upwards to form the upper margin of the candal fin. It carries an overlapping series of small fulera.

The candal fin was very large, powerful, and bilobed, the upper lobe being a little the longer. The margin of the lower lobe is supported by stout closely-articulated spinous rays which run out upon it one after the other. They gradually diminish in strength towards the middle of the fin, where they become filamentous almost to their base. They still go on decreasing along the upper lobe, ultimately becoming filamentous. The scales stop at the point of origin of the fin rays, but are continued along the body pedicle, their direction only being changed. On the body they are arranged in rows which slope obliquely backwards and downwards; on the body pedicle they pass backwards and upwards. Their shape changes also from the typical rhombic condition to an elongated lozenge shape.

The extreme fringe of the tail has been destroyed, so that its length cannot be accurately determined. It would appear, however, to have been about 2½ inches long from the root of the tail, the fish being about 11 inches long.

The anal fin is much stronger and larger than that of the type-specimen, and, as we have already stated, runs back almost to the origin of the ventral lobe of the tail.

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The additional information respecting the species obtainable from the specimens we have described may be summarised as follows:—

The species possessed a powerful heterocercal tail of a truly Palæoniscoid type, and a large anal fin, placed very far back. Further, the clavicular element and possibly the cranial membrane bones bore an ornament of fine concentrically-disposed ridges, the former being long, narrow, and thin.

A later examination of the blocks of anthracite at the Geological Society's Rooms resulted in my finding a block bearing the impression of a fin and a slight trace of bone ornament. I succeeded in fitting the block to that mass of anthracite upon which is impressed the forepart of the body and a portion of the head, when the following additional features could be established.

The supposed clavicular elements were correctly determined, the post-temporal, supra-clavicular, and clavicular being well defined, all presenting the ornament already spoken of. In front of the supra-clavicular and clavicular elements a small patch of ornament indicated the position of an interopercular.

Ventrally, they are succeeded by a large number of branchiostegal rays. These latter are but faintly defined, but seem to number about twenty. In all probability more were originally present, since they are cut off by the edge of the block of anthracite at the middle of the dentary. The posterior half of the dentary has left the cast of its ornament upon the coal. This consists of fine ridges which circle round its articular end, and are fairly parallel to the upper and lower borders.

From the cast we assume that the dentary was a somewhat thin bone, concave on its inner side, and of no great depth.

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Behind the branchiostegal rays is a small anterior portion of the pectoral fin.

It is worthy of remark that in the great number of the branchiostegal rays, and the nature of the ornament of the dentary, there is an approximation to what is seen in Nematoptychus.

A vote of thanks to Mr. Bolton for his interesting papers was passed on the motion of the President, seconded by Professor Boyd Dawkins.

The discussion on these papers was deferred.

NOTES ON SOME FOSSIL PLANTS FROM THE LANCASHIRE COAL MEASURES.

(SECOND PAPER.*)

By Robert Kidston, F.R.S.E., F.G.S.

Since the publication of my previous paper on the Flora of the Lancashire Coal Measures, in Part XIII., Vol. XXI., of the Transactions of this Society, I have had the opportunity of examining some additional collections of Lancashire Fossil Plants, from which the following notes have been prepared.

In all these investigations I have been much assisted by your Secretary, Mr. Stirrup, who, before my last visit to the district, much facilitated my work by kindly making arrangements for my examining any specimens of Lancashire Fossil Plants in the possession of local geologists, and by accompanying me on my visits.

One cannot emphasize too strongly the absolute necessity of local geologists assisting the Society in its endeavours to work up the Lancashire Coal Flora. It is a work that can

* For first paper see *Trans. Geol. Soc., Manchester, Vol. XXI., p.* 401, 1892.

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only be done by those living on the spot, and able to embrace any opportunity for collecting specimens that may present itself.

And not only good specimens should be kept, but also what may appear to the collector as imperfect or fragmentary ones, as these latter often exhibit some missing point which may be of peculiar interest to the botanist.

I have to express my thanks to all those who have helped in our investigations, and whose names are mentioned in the following report. Perhaps the most interesting collection examined since the previous paper was written, is that made some time ago by Mr. J. Neild, Oldham, from the "Forest Bed" there.

It need scarcely be added, that I shall have great pleasure in continuing these notes so long as the members of your Society provide me with the material from which to prepare them.

I.—SPECIMENS IN THE COLLECTION OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN, MUSEUM, JERMYN STREET, LONDON.

My thanks are due to Sir Archibald Geikie for permission to examine these specimens.

MIDDLE COAL MEASURES.

CALAMARIÆ.

Calamites undulatus, Sternb.

Hor. ?

Loc. Lomaxfold, Little Lever, Bolton.

Calamites Cistii, Brongt.

Hor. ?

Loc. Lomax Brow, Peel, 4 miles S.W. of Bolton.

Calamites Suckowii, Brongt.

Hor. ?

Locs. Green, on the river Irwell, near Bolton.
Old Hall, ¾ mile S.W. of Little Lever, Bolton.

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Annularia radiata, Brongt.

Hor. 4ft. Mine.

Loc. South side of Bolton.

Hor.?

Loc. Darcy Lever Pit, 1 mile S.E. of Bolton.

FILICACEÆ.

Sphenopteris trifoliolata, Artis sp.

Hor.?

Loc. Hulton Colliery, 3 miles S.W. of Bolton.

Mariopteris muricata, Schl. sp.

Hor. 4ft. Mine.

Loc. South side of Bolton.

Hor.?

Locs. Shoretop, 1 mile S. of Little Lever, Bolton.
Hulton Colliery, 3 miles S.W. of Bolton.

Neuropteris heterophylla, Brongt.

Hor. Yard Coal.

Loc. Old Hall, ¾ mile S.W. of Little Lever, Bolton.

Hor. 4ft. Mine.

Loc. South side of Bolton.

Hors.?

Locs. Darcy Lever, 1 mile S.E. of Bolton.
Shoretop, 1 mile S.E. of Little Lever, Bolton.
Lomaxfold, Little Lever, Bolton.

Neuropteris acuminata, Schl. sp.

Hor.?

Loc. Hulton Colliery, near Bolton.

Alethopteris lonchitica, Schl. sp.

Hor. 4ft. Mine.

Loc. South side of Bolton.

Hor.?

Locs. Hulton Colliery, 3 miles S.W. of Bolton.
Shoretop, 1 mile S. of Little Lever, Bolton.
Hacken Farm, 1 mile S. of Bolton.

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Pecopteris Miltoni, Artis sp.

Hor. ?

Loc. Darcy Lever, Bolton.

SPHENOPHYLLEÆ.

Sphenophyllum cuneifolium, Sternb. sp.

Hor. ?

Loc. Hulton Colliery, 3 miles S.W. of Bolton.

Sphenophyllum trichomatosum, Stur.

Hor. ?

Loc. Shoretop, 1 mile S.E. of Little Lever, Bolton.

LYCOPODIACEÆ.

Lepidodendron ophiurus, Brongt.

Hor. 4ft. Mine.

Loc. South side of Bolton.

Hor. ?

Locs. Hall, ½ mile from Little Lever, Bolton.
Hulton Colliery, 3 miles S.W. of Bolton.

Lepidodendron Wortheni, Lesqx.

Hor. ?

Loc. Halshaw Moor, near Farnworth, Bolton.

Lepidostrobus variabilis. L. and H. (Aggr.)

Hor. Yard Coal. (Below Cannel Mine.)

Loc. Hulton Colliery, 3 miles S.W. of Bolton.

Sigillaria scutellata, Brongt.

Hor. ?

Loc. ¼ mile E. of Tonge, Bolton.

CORDAITEÆ.

Cordaites principalis, Germar sp.

Hor. ?

Loc. Shoretop, 1 mile S.W. of Little Lever, Bolton.

Trigonocarpus Parkinsoni, Brongt.

Hor. 4 feet Mine.

Loc. South side of Bolton.

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ROOTLETS.

Pinnularia capillacea. L. and H.

Hor. 4 feet Mine.

Loc. South side of Bolton.

LOWER COAL MEASURES.

CALAMARIÆ.

Calamitina (Calamites) undulatus, Sternb. sp.

Hor. ?

Loc. Eagley Shore, 2 miles N. of Bolton.

FILICACEÆ.

Sphenopteris obtusiloba, Brongt.

Hor. ?

Loc. Eagley Shore, 2 miles N. of Bolton.

Mariopteris muricata, Schl. sp.

Hor. ?

Loc. Eagley Shore, 2 miles N. of Bolton.

Neuropteris heterophylla, Brongt.

Hor. ?

Loc. Eagley Shore, 2 miles N. of Bolton.

LYCOPODIACEÆ.

Bothrodendron minutifolium, Boulay sp.

Hor. ?

Loc. Eagley Shore, 2 miles N. of Bolton.

II.—SPECIMENS COLLECTED BY MR. J. NIELD, OLDHAM.

Fossil Plants from Oldham Edge, Oldham :—

Hor. The "Forest Bed" lies about 16 yards below "Hollingworth Mine" of Oldham, or about 29 below the "Lower Bent or Peacock Mine" of Ashton-under-Lyne.*

* See Dickinson's Section, *Trans. Manchester Geol. Soc.*, 1863, Part VI., Vol. IV., and Hull's Vertical Section Sheet 33, "Glodwick, near Oldham."

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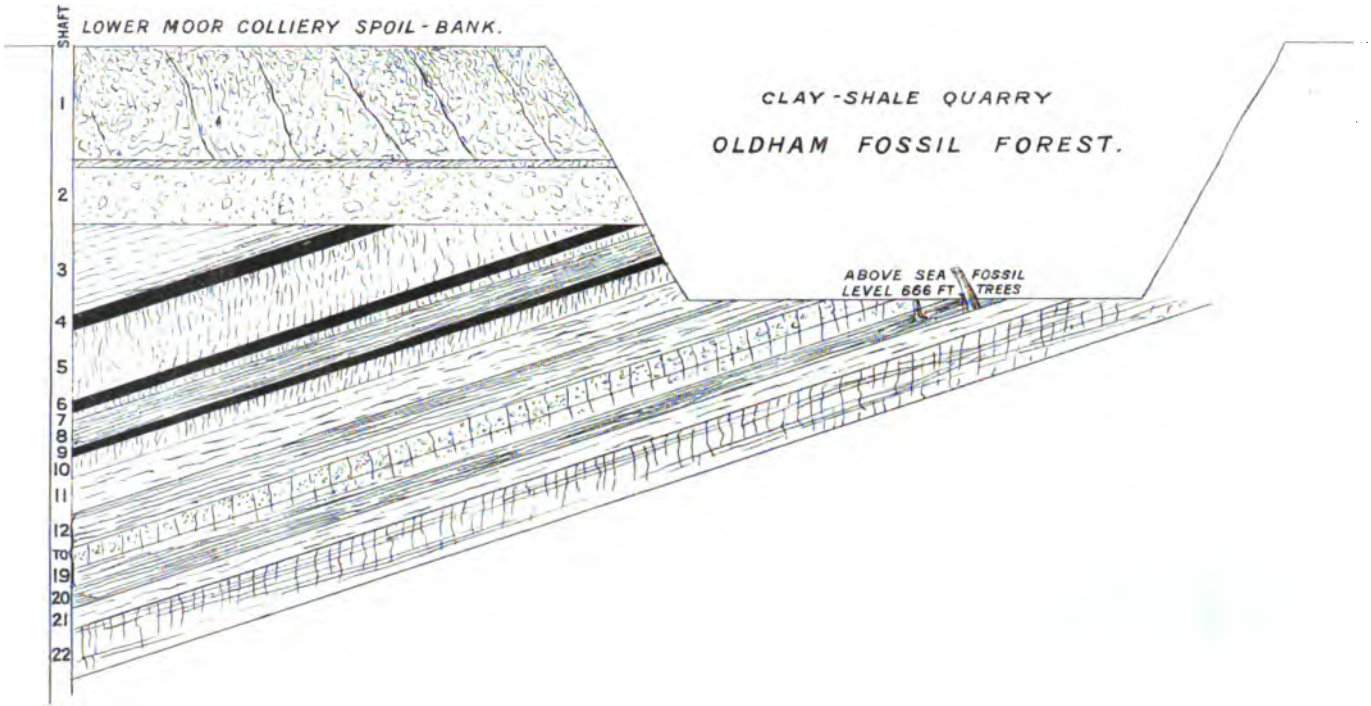

Vertical Scale,- 1 Inch = 60 Feet.
Horizontal " " " = 90 Feet.

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MIDDLE COAL MEASURES.

As the "Forest Bed" has proved so rich in Fossil Plants, I give here a section of the strata (*see plate*) exposed at Oldham Edge, which was prepared by Mr. H. Robinson, and communicated to me by Mr. George Wild, of Bardsley, showing the position of the "Forest Bed," with upright trunks.

This bed should be very carefully collected from whenever any opportunities occur.

(The following description of the "Forest Bed" section has been prepared by Mr. George Wild.)

DETAILED SECTION "OLDHAM FOSSIL FOREST."

		Ft.	In.
1	Shale-heap (colliery spoil-bank)	39	0
2	Alluvial Clay	20	0
3	Shale, roof of Lower Bent (Peacock Mine)	26	0
4	LOWER BENT (PEACOCK) MINE	2	4½
5	Dark Bass and Blue Shale	24	7
6	COAL	1	3
7	Warrant-Earth (Coal Seat)	3	9
8	Strong Grey Shale	9	4
9	COAL (Hollingworth Mine)	0	11
10	Fire-clay or Grey Warrant-Earth (Seat)	7	9
11	Brown Fire-clay	0	2
12	White Shale	12	4
13	White Rock	1	6
14	Grey Shale, with ironstone balls	14	0
15	Ditto ditto	1	0
16	Grey Rock	2	0
17	Grey Shale	1	0
18	Grey Rock	1	0
19	Grey Shale	1	0
20	Grey Rock	5	6
	Fossil Trees (Trunk Casts) were found at various horizons in this stratum, and plant remains in this and adjoining strata.		
21	Grey Shale	6	6
22	Dark Warrant (Seat of little coal)	17	0
		26	

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CALAMARIÆ.

Calamites ramosus, Artis.
Calamocladus equisetiformis, Schl. sp.

FILICACEÆ.

Sphenopteris Sauveuri, Crépin.
„ *Footneri*, Marrat.
„ *Zobelli*, Göpp.
„ *Sternbergii*, Ett. sp.
„ *furcata*, Brongt.
Zeilleria delicatula, Sternb. sp.
Corynepteris coralloides, Gutbier sp.
Mariopteris muricata, Schl. sp., *forma nervosa* (Brongt. sp.)
Dactylotheca plumosa, Artis sp.
Alethopteris lonchitica, Schl. sp.
„ *decurrens*, Artis sp.
Pecopteris Miltoni, Artis sp.
Neuropteris heterophylla, Brongt.

SPHENOPHYLLEÆ.

Sphenophyllum cuneifolium, Sternb. sp.
„ „ „ *var. saxifragæfolium*, (Sternb. sp.)

LYCOPODIACEÆ.

Lepidodendron Landsburgii, Kidston.

Lepidodendron Landsburgii, Kidston. Trans. Roy. Soc., Edin., 1893, Vol. XXXVII., Part II., p. 338. Pl. III., figs. 9, 9*a*, 10, 10*a*, 10*b*.

Lepidodendron rimosum, Sternb.
„ *Haidingeri*, Ett.
Lepidophyllum majus, Brongt.
„ *lanceolatum*, L. and H.
Sigillaria scutellata, Brongt.
„ *discophora*, König sp.
Stigmaria ficoides, Sternb. sp.

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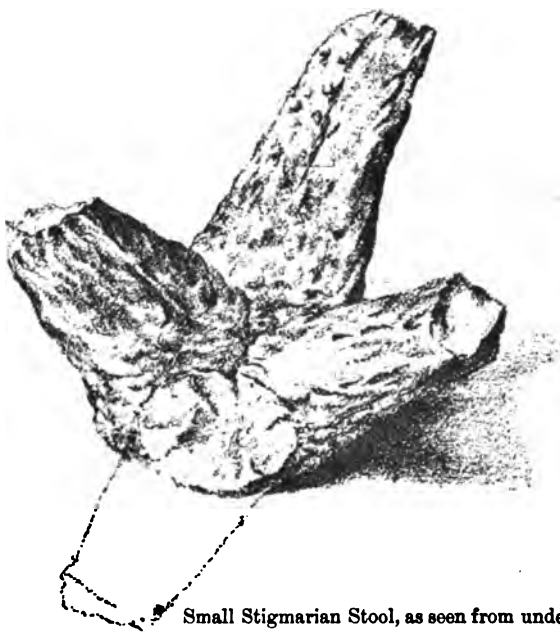
One of the most interesting specimens of a *Stigmaria* (*see illustration below*) yet found was that got by Mr. Neild from this bed. It is a small Stigmarian stool of the following dimensions:—

Small Stigmarian Stool, in natural position.



Small Stigmarian Stool, as seen from underneath.

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Largest diameter of stem, 4 inches.

Primary roots:—

I. Length, 7 inches from centre of "cross" at base of stem.

II. 3¾ inches from centre of "cross" at base of stem.

III. 3½ inches from centre of "cross" at base of stem.

IV. Broken off.

The ordinary stigmarian scars are well shown on the forks close up to the cross-like division of the stem, where it divides into the four primary roots.

CORDAITEÆ.

Cordaites borassifolius, Sternb. sp.

ROOTLETS.

Pinnularia capillacea. L. and H.

III.—SPECIMENS COLLECTED BY MR. J. NEILD FROM OTHER LOCALITIES.

MIDDLE COAL MEASURES.

CALAMARIÆ.

Calamitina (Calamites) approximata, Brongt.

Hor. Blendfire Rock = Rusty Mine of Ashton-under-Lyne.

Loc. Oldham Edge, Oldham.

Calamites Suckowii, Brongt.

Hor. Blendfire Rock.

Loc. Oldham Edge, Oldham.

Calamocladus charæformis, Sternb. sp.

Hor. Peacock Mine = Lower Bent Mine, Oldham.

FILICACEÆ.

Neuropteris obliqua, Brongt. sp.

Hor. Peacock Mine.

Loc. Rocher, Ashton-under-Lyne.

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Mariopteris muricata, Schl. sp.
Hor. Peacock Mine.
Loc. Rocher, Ashton-under-Lyne.
Alethopteris lonchitica, Schl. sp.
Hor. Peacock Mine.
Loc. Rocher, Ashton-under-Lyne.

LYCOPODIACEÆ.

Lepidodendron obovatum, Sternb.
Hor. Peacock Mine.
Loc. Rocher, Ashton-under-Lyne.
Lepidodendron obovatum, Sternb.
Hor. ?
Loc. Oldham.
Sigillaria mamillaris, Brongt.
Hor. ?
Loc. Oldham.
Sigillaria scutellata, Brongt.
Hor. ?
Loc. Oldham.
Sigillaria elongata, Brongt.
Hor. ?
Loc. Oldham.
Sigillaria trigona, Sternb. sp.
Hor. ?
Loc. Oldham.
Favularia trigona, Sternb. Essai flore monde prim. I., Fasc. IV., p. 13, 1826.
Lepidodendron trigonum, Sternb. Essai flore monde prim. I., Fasc. I., p. 23, Pl. XI., Fig. I., 1820.
1876. *Sigillaria trigona*, Feistm., Vers. d. böhm. Ablager. III., Abeth., Pl. IX., Figs. 3, 4, and 5. (*At explanation to plate Feistmantel says, "That it is nothing other than Sigillaria tessellata, analogous* to the *Sigillaria ichthyolepis* figured by Corda.)

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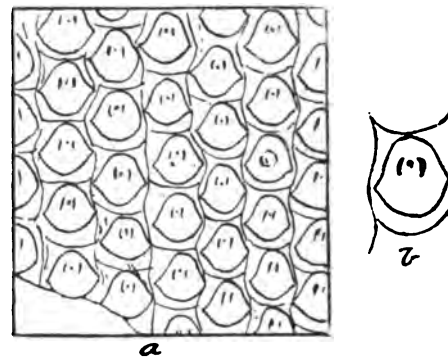
DESCRIPTION :—Stem-ribbed, furrows flexuous; leaf-scar pyriform, separated by only a slight interval, lateral angles prominent, rounded or truncate on upper margin, and rounded below; cicatricules three, central punctiform, the two lateral lunate. The leaf-scars are separated by a transverse lunate furrow passing immediately above them, which extends across the entire width of the rib. The leaf scar is thus situated at the upper end of a compartment whose upper limit is bounded by a concave furrow, and whose lower limit is circumscribed by a convex line.

REMARKS :—*Sigillaria trigona* differs from *Sigillaria tessellata* in the transverse furrows on the ribs extending across their whole width, and in these furrows not being straight but curved. The leaf-scars are also much more truly pyriform.



Sigillaria trigona Sternb. sp. *a* Nat size. *b* Leaf-scar enlarged. *Loc.* Oldham.

From *Sigillaria mammillaris*, Brongt., to which *Sigillaria trigona* has also some affinity, it is separated by the absence of the two short lines of transverse wrinkles which descend from the lower angles of the leaf-scars and the division of the ribs into compartments.

Sigillaria trigona has been united to *Sig. Dournaisii*, Brongt., but not without doubt, by Brongniart* and Unger,† but Goldenberg‡ places *Sigillaria trigona* under *Sigillaria Dournaisii*, Brongt., without any reservation.

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* *Hist. d. végét. foss.*, p. 441.

† *Synop. plant. foss.*, 1845, p. 236; also *Genera et species plant. foss.*, p. 236, 1850.

‡ Goldenberg, *Flora saræpont. foss. Heft. II.*, p. 28, 1857.

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Several specimens of *Sigillaria trigona*, which have lately come into my hands have led me to reject this course and to regard the plant as a distinct species.

Sigillaria Dournaisii, Brongt., appears to be only a form of *Sigillaria mamillaris*, from which *Sigillaria trigona* is evidently distinct.

Sigillaria tessellata, Brongt.
Hor. ?
Loc. Oldham.

Sigillaria discophora, König. sp.
Hor. ?
Loc. Oldham.

CORDAITEÆ.

Artisia transversa, Artis sp.
Hor. Blendfire Rock.
Loc. Oldham.

ROOTLETS.

Pinnularia capillacea, L. and H.
Hor. Peacock Mine.
Loc. Rocher, Ashton-under-Lyne.

LOWER COAL MEASURES.

LYCOPODIACEÆ.

Sigillaria elegans, Sternb. sp.

Favularia elegans, Sternb. Vers. I. Fasc. IV., p. 14, pl. lii., fig. 4, 1826.

Favularia, Williamson. Phil. Trans. 1872, p. 221, pl. xxxi., fig. 58.

Sigillaria elegans, Brongt. Hist. d. Végét. Foss., p. 438, pl. cxlvi., fig. 1, pl. clv., pl. clviii., fig. 1. Zeiller, Flore Foss. d. Bassin Houil. d. Valen., p. 582, pl. lxxxvii., figs. 1-4.

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The specimen recorded here is that of which Professor Williamson has figured a small portion in his memoir mentioned above. It shows a portion of the bark with a verticil of cone scars.

Hor. "Coal Ball," or "Baumpot," in Upper Foot Mine.
Loc. Near Oldham.

CORDAITEÆ.

Trigonocarpus Parkinsoni, Brongt.
Hor. "Coal Ball" in Upper Foot Mine.
Loc. Near Oldham.

IV.—SPECIMENS COLLECTED BY MR. GEORGE WILD, BARDSLEY, ASHTON-UNDER-LYNE.

MIDDLE COAL MEASURES.

CALAMARIÆ.

Calamitina varians, Sternb. sp.
Hor. Roof of Peacock Mine = Lower Bent Mine of Oldham.
Loc. Bardsley.

Calamitina undulata, Sternb. sp.
Hor. Below 5½in. Coal.*
Loc. Bardsley.

FILICACEÆ.

Neuropteris gigantea, Sternb.
Hor. Below Slaty Coal of Fulledge, which is immediately below 200 yards Bed of Mr. Dickinson's section.
Loc. Burnley.

Alethopteris lonchitica, Schl. sp.
Hor. Below New Mine = Neddy Mine, Oldham.
Loc. Ashton-under-Lyne.

* See Mr. Wild's Section, Bardsley Colliery, *Trans. Man. Geol. Soc.*, Vol. XVIII., p. 462.

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Lycopodiaceæ.

Bothrodendron punctatum. L. and H.
Hor. Saltpetre Mine = Great Mine of Oldham.
Loc. Ashton Moss, Ashton.

Sigillaria discophora, König sp.
Hor. Low Bottom Bed. (*See Dickinson's Sections at Fulledge for position of bed*).
Loc. Burnley.

LOWER COAL MEASURES.

Lepidodendron obovatum, Sternb.
Hor. Dirty Yard Mine, below Mountain Mine.
Loc. Rishton, near Blackburn.

V.—SPECIMENS IN OLDHAM MUSEUM.

MIDDLE COAL MEASURES.

Calamariæ.

Calamitina varians, Sternb. sp.
Hor. Blendfire Rock.
Loc. Oldham Edge, Oldham.

Calamites ramosus, Artis.
Hor. Blendfire Rock.
Loc. Oldham Edge, Oldham.

Filicaceæ.

Alethopteris valida, Boulay.
Hor. Roof of Peacock Coal.
Loc. Glodwick, Oldham.

Note.—This collection contains two exceedingly fine specimens of this species.

Mariopteris muricata, Schl. sp.
Hor. Roof of Peacock Mine.
Loc. Glodwick, Oldham.

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LYCOPODIACEÆ.

Bothrodendron minutifolium, Boulay sp.

Hor. Peacock Mine = Lower Bent Mine of Oldham.

Loc. Glodwick, near Oldham.

Hor. Roof above Saltpetre Mine.

Loc. Ashton Moss, Ashton-under-Lyne.

Sigillaria tessellata, Brongt.

Hor. About position of Peacock Mine.

Loc. Chamber Lane, Oldham.

CORDAITEÆ.

Artisia transversa, Artis.

Hor. Roof of Saltpetre Mine.

Loc. Ashton Moss, Ashton-under-Lyne.

VI.—SPECIMENS COLLECTED BY MR. JOHN LORD, BACUP.

LOWER COAL MEASURES.

LYCOPODIACEÆ.

Sigillaria discophora, König. sp.

Hor. Roof of Gannister Mine.

Loc. Old Clough, Bacup.

Lepidophloios, sp. (Halonial condition).

Hor. Roof of Gannister Mine.

Loc. Stacksteads, Bacup.

VII.—SPECIMENS COLLECTED BY MR. C. ROEDER.

MIDDLE COAL MEASURES.

(Horizons uncertain.)

CALAMARIÆ.

Calamocladus charæformis, Sternb. sp.

Loc. Alkrington, near Middleton.

Calamocladus equisetiformis, Schl. sp.

Loc. Alkrington, near Middleton.

FILICACEÆ.

Alethopteris decurrens, Artis. sp.

Loc. Peel Delph, near Bolton.

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Alethopteris lonchitica, Schl. sp.

Loc. Bridgewater Collieries, Worsley.

Dactylotheca plumosa, Artis. sp.

Loc. Bridgewater Collieries, Worsley.

Neuropteris heterophylla, Brongt.

Loc. Darcy Lever, near Bolton—on red hematite shale.

LYCOPODIACEÆ.

Lepidodendron aculeatum, Sternb.

Loc. Moston Pit, near Newton Heath.

VIII.—SPECIMENS COLLECTED BY MR. J. W. CROSTON, PRESTWICH.

MIDDLE COAL MEASURES.

Zeilleria delicatula, Sternb. sp.

Dactylotheca plumosa, Artis. sp.

Hor. Bed below the sandstone on which the trees stand, that were described by Mr. Bowman in 1841.* (A little above Doe Mine).

Loc. Dixon Fold, Stoneclough, near Manchester.

IX.—SPECIMENS IN OWENS COLLEGE, MANCHESTER.

Collected and contributed by Mr. JAMES TONGE, F.G.S.†

MIDDLE COAL MEASURES.

CALAMARIÆ.

Calamitina undulata, Sternb. sp.‡

Hor. Yard Mine.

Loc. Hulton Colliery, Bolton.

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* *Trans. Man. Geol. Soc., Vol. I., p. 112.*

† In reference to this Collection, Mr. Tonge begs to acknowledge the indebtedness of the Society for specimens given or sent to him by the following gentlemen:—Messrs. J. Grundy, W. Saint, J. Unsworth, J. Ainsworth, J. Barton, H. Bramall, R. Clay, J. Grundy, W. Horrobin, W. Kearsley, R. Walkden, J. Pilkington, and G. Jameson.——The local names of the mines and their stratigraphical position will be seen by reference to J. Dickinson's Sections of the Coal Strata of Lancashire. *Trans. Man. Geol. Soc.*, Vol. IV., Part 6. 1862–3.

‡ See *Trans. York. Nat. Union*, Part 18, pp. 99-100, 1893.

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Calamites Suckowii, Brongt.
Hor. Peacock Mine = Lower Bent of Oldham.
Loc. Astley Deep Pit, Dukinfield, Ashton-under-Lyne.
Calamites Cistii, Brongt.
Hor. Wigan 9ft. Seam = Trencherbone of Clifton.

FILICACEÆ.

Sphenopteris furcata, Brongt.
Hor. Roof of Shuttle Mine.
Loc. Agecroft Colliery, near Manchester.
Alethopteris lonchitica, Schl. sp.
Hor. $\frac{5}{4}$ Mine.
Loc. Darcy Lever, near Bolton.
Mariopteris muricata, Schl. sp.
Hor. Arley Mine.
Loc. Hulton Colliery, near Bolton.
Hor. Yard Mine.
Loc. Hulton Colliery, near Bolton.
Hor. King Coal.
Loc. Kirkless Colliery, Wigan.
Mariopteris muricata, Schl. sp., *forma* nervosa (Brongt. sp.)
Hor. King Coal.
Loc. Kirkless Colliery, Wigan.
Neuropteris heterophylla, Brongt.
Hor. Doe Mine.
Loc. Rosehill Colliery, Bolton.
Neuropteris obliqua, Brongt. sp.
Hor. Yard Mine.
Loc. Hulton Colliery, near Bolton.

LYCOPODIACEÆ.

Lepidodendron ophiurus, Brongt.
Hor. Crumbouke Mine.
Loc. Tyldesley.

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Hor. Rams Mine.
Loc. Tyldesley.

Lepidodendron aculeatum, Sternb.
Hor. Peacock Mine = Lower Bent Mine of Oldham.
Loc. Astley Deep Pit, Dukinfield, Ashton-under-Lyne.

Lepidodendron Wortheni, Lesqx.
Hor. Yard Mine.
Loc. Hulton Colliery, near Bolton.

Sigillaria ovata, Sauveur.
Hor. Brassy Mine.
Loc. Worsley.

Sigillaria tessellata, Brongt.
Hor. Brassy Mine.
Loc. Worsley.

Lepidophyllum lanceolatum, L. and H.
Hor. Yard Mine.
Loc. Hulton Colliery, near Bolton.

Stigmaria ficoides, Sternb. sp.
Hor. Trencherbone Mine.
Loc. Kearsley Colliery, near Bolton.

LOWER COAL MEASURES.

FILICACEÆ.

Mariopteris muricata, Schl. sp.
Hor. Sandrock Mine.
Loc. Ashworth Colliery, near Heywood.

LYCOPODIACEÆ.

Stigmaria ficoides, Sternb. sp.
Hor. Lower Mountain Mine.
Loc. Darwen, near Blackburn.

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X.—SPECIMENS IN THE MUSEUM OF THE NATURAL HISTORY SOCIETY, BACUP.

LOWER COAL MEASURES.

FILICACEÆ.

Mariopteris muricata, Schl. sp.
Hor. Roof of Gannister Mine.
Loc. Old Meadows Pit, Bacup.

Alethopteris lonchitica, Schl. sp.
Hor. Roof of Gannister Mine,
Loc. Old Clough Colliery, Bacup.

Megaphyton, sp.
Hor. Roof of Gannister Mine.
Loc. Old Meadows Pit, Bacup.

This specimen is 3 feet 1 inch long and 7 inches wide. It shows eight frond scars, which are about 3 inches long and 1¾ inches wide.

LYCOPODIACEÆ.

Lepidodendron ophiurus, Brongt.
Hor. Roof of Gannister Mine.
Loc. Stacksteads, Bacup.

Lepidodendron obovatum, Sternb.
Hor. Roof of Gannister Mine.
Loc. Old Meadows Pit, Bacup.

Lepidodendron aculeatum, Sternb.
Locs. Whittaker Clough, Bacup; Old Meadows Pit, Bacup.

Sigillaria discophora, König.
Hor. Roof of Gannister Mine.
Loc. Old Meadows Pit, Bacup.

Sigillaria tessellata, Brongt.
Hor. Roof of Gannister Mine.
Loc. Old Meadows Pit, Bacup.
Hor. Woodhead Hill Rock.
Loc. Towers Clough, Bacup.

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Sigillaria mamillaris, Brongt.
Hor. Roof of Gannister Mine.
Loc. Old Meadows Pit, Bacup.

Lepidophloios acerosus, L. and H., sp.
Hor. Roof of Gannister Mine.
Loc. Old Meadows Pit, Bacup.

CORDAITEÆ.

Artisia approximata, Brongt.
Hor. Under the Gannister Rock.
Loc. Whittaker Clough, Bacup.

Artisia transversa, Artis. sp.
Hor. Under the Gannister Rock.
Loc. Whittaker Clough, Bacup.

To the previous paper I appended a list of all the Lancashire Carboniferous Plants known to me at the time. That list contained 73 species, and two forms or varieties. To these must now be added the following 14 species and 1 variety.

CALAMARIÆ.

Calamocladus charæformis, Sternb. sp.

FILICACEÆ.

Corynepteris coralloides, Gutbier sp.
Sphenopteris Zobelli, Göpp.
Dactylotheca plumosa, Artis. sp.

SPHENOPHYLLEÆ.

Sphenophyllum cuneifolium, Sternb., var. *saxifragæfolium*.
Sphenophyllum trichomatosum, Stur.

LYCOPODIACEÆ.

Lepidodendron Worthenii, Lesqx.
Lepidodendron rimosum, Sternb.
Lepidodendron Landsburgii, Kidston.

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Bothrodendron punctatum, L. and H.
Sigillaria scutellata, Brongt.
Sigillaria elongata, Brongt.
Sigillaria trigona, Sternb. sp.

CORDAITEÆ.

Cordaites borassifolius, Sternb. sp.
Artisia transversa, Artis, sp.

The thanks of the meeting were voted to Mr. Kidston for his valuable communication, on the motion of Mr. STIRRUP, seconded by Professor DAWKINS.

THE CARBONIFEROUS INSECTS OF COMMENTRY, FRANCE.

BY MR. MARK STIRRUP, F.G.S.

It is now nearly ten years ago* since I had the pleasure of translating and presenting to the Society on behalf of my friend, Mr. Charles Brongniart, F.E.S., of the Natural History Museum, Paris, an outline or introductory sketch of the species of fossil insects which had then been recently discovered in the fine shales or ancient muds which accompany the coal beds in the Mines of Commentry.

In December, 1890,† I again brought the subject forward as an incentive to fossil collectors and explorers in our local coal measures, referring at the same time to later observations, which Mr. Brongniart had made, describing, in some of these fossil insects, curious characters which are not found in living types.

Although the Society has been favoured with these preliminary sketches of the insect fauna of Commentry, yet

* *Trans. Manchester Geol. Soc., Vol. XVIII., page 269.*
† *Trans. Manchester Geol. Soc., Vol. XXI., page 93.*

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several of the members looked forward with deep interest to fuller details and to the completion of the monograph, which it was understood Mr. Brongniart was preparing.

I have now the pleasure of announcing that the work, so long expected, is at last finished, is in the printers' hands, and will appear in a few weeks. It forms a volume of 500 pages in quarto, and an atlas of 37 plates in folio.

Sixty new genera and 100 new species are therein described. The work also contains a detailed study of the nervation of the Neuroptera, Orthoptera, and the living Fulgoridæ.

The Cockroaches which occur in great number at Commentry, and which appear to have been the insect patriarchs of primæval time, are, I understand, reserved for subsequent description.

Our knowledge of palæozoic insects has been hitherto scanty, owing to the rarity of their preservation and the fragmentary condition, for the most part, in which their fossilized remains have been found.

This has been all changed by the remarkable deposit at Commentry, which has yielded ten times more specimens than all other localities in Europe and America put together.

Not only are specimens more abundant, but they are found in a state of entirety and preservation which is most remarkable, owing doubtless in a great measure to the fineness of the matrix in which they are imbedded, and the conditions under which they were entombed.

The value of Mr. Brongniart's work and its interest, not only to palæontologists and entomologists, but to scientific enquirers in other fields of research, can not be overstated, for while affording an insight into an insect fauna, rich beyond comparison, it suggests by implication clearer views of the external surroundings then existing,—the ancient physical features of the country and the climatic conditions.

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The carboniferous woodlands have been represented as dark and monotonous; and although void, as we know them to have been of flowers and the sweet song of birds, yet the forests were neither tenantless nor voiceless, for the hum and chirp of a varied insect life were heard among them.

Mr. Samuel H. Scudder, the eminent American Entomologist, who has recently had the opportunity of examining in Paris the material upon which Mr. Brongniart has been working for so many years, (a pleasure I myself enjoyed some three or four years ago), in an article in the *American Journal of Science* of February last, writes to the following effect:—"Within the last two or three days, I have had the opportunity, through the kindness of Mr. Brongniart, of seeing not only a considerable part of this collection, but also the illustrations prepared by Mr. Brongniart himself from the choicest specimens; illustrations made with a care and exactitude which leave nothing to be desired, and which are now nearly completed after a labour of ten years, so that we may hope soon to be favoured with his final work. Leaving the cockroaches out of account, to which Mr. Brongniart will give his attention later, the number of these illustrations, their variety, the extraordinary character of the insects themselves, and their rare perfection, leave not the least room for doubt that when his work appears our knowledge of palæozoic insects will have been increased three or four-fold at a single stroke and an entirely new point of departure for the future opened. No former contribution in this field can in any way compare with it, nor even all former contributions taken together. Besides it will offer such a striking series of strange forms as cannot fail to awaken the attention of the least incurious. One may not enter into details, but mention may simply be made of one species, regarded by Mr. Brongniart as one of the forerunners of the dragon-flies, in which the wings have

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an expanse of considerably more than two feet (or about 70 centimetres) and of which several specimens are preserved. It is a veritable giant among insects."

Mr. Crankshaw moved that the thanks of the meeting be given to Mr. Stirrup for his paper, and expressed his pleasure at again seeing Mr. Stirrup amongst them.

Professor Dawkins: I have pleasure in seconding the motion. We are all quite pleased to see Mr. Stirrup's familiar face here again, and hope he will be long with us, and live to do the kind of work he has done for us for so many years.

The President: I have great pleasure in putting it to the meeting. It is a pleasure to see Mr. Stirrup restored to health after such a long illness, and I trust he will be able to give us some more contributions like those we have had from him. He has been a prolific writer for the benefit of the Society in the past, and I have no doubt he will be able to give us valuable information in the future.

The vote of thanks was unanimously passed.

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INDEX TO VOL. XXII.

PAGE

Additions to the Library 18, 139, 315, 374
Annual Meeting, October, 1892 1
,, ,, ,, 1893.. 359
Annual Report of the Council, 1892 1
,, ,, ,, 1893 359

BELL, THOMAS:—
Section of Strata Sunk through in No. 2 Shaft, Deaf Hill Colliery, Co. Durham, for the Trimdon Coal Company 191

BLACKWELL, G. G.:—
Notes on Bauxite of County Antrim, and its uses in the manufactures 525
Discussion.. 527

BOLTON, HERBERT:—
Notes on Plant and Fish Remains from the Jarrow Colliery, County Kilkenny 613
Notes on the Myriolepis Hibernica Traq. 628

CAIRNS, ROBERT:—
Presentation of Fossils 447

CALDWELL, GEORGE:—
Fossil Plants from the Cannel of the Wigan Four Feet Mine 211

CRANKSHAW, JOSEPH:—
Notes on Hurd's Patent Pneumatic Electric Coal Cutting Machine 558
Discussion.. 569

DAWKINS, W. BOYD:—
The Coalfields of New South Wales 160
Discussion.. 169
On the South-Eastern Coalfield at Dover 488
Discussion.. 507
On the Geology of the Isle of Man 590
Discussion.. 606

Digitized by Google

De Rance, C. E.:— PAGE
The Glacial Drifts 49
On the Relation of Geology to the Population and Agriculture of England and Wales 85
Discussion 110, 181
Map of River Basins Presented to Society 180
The Glacial Drifts Deposits at Sandbach 235, 268
Results of the Salt Union Boring at Marston, near Northwich 269
Discussion.. 292
On the Boring for Coal on the Freeholders' Estate at Hazel Grove.. 452
Dickinson, Joseph:—
On Outbursts of Soft Coal and Gas in the Royley Seam, at the Nook Pit, Broad Oak Colliery, Ashton-under-Lyne 239
Discussion 255, 332
Notes on Mr. De Rance's Paper on "The Boring for Coal on the Freeholders' Estate at Hazel Grove".. 548
Discussion.. 551
Globular Concretions from the Coal Measures of Lancashire. Exhibited by Messrs. Clay, Stirrup, and Wild 66
Greenwell, G. C.:—
On Ironstone Deposits near Dover 553
Greenwell, G. C., Jun.:—
Bitumen from a Coal Seam at Poynton, near Stockport 444
Gresley, W. S.:—
Reply to Discussion on a Typical Section of the "Main" Coal of the Moira Division of the Leicestershire Coalfield 74
Discussion 78
Outburst of Soft Coal and Gas 429
Discussion 433
Grundy, James:—
How and what to observe in and about mines, with some Practical Tests 113
Discussion 138

Digitized by Google

GRUNDY, THOMAS:— PAGE
On the Deepening of a Shaft, Under the Cages at Wigan Junction Colliery 303
Discussion 306

HALL, HENRY:—
Mis-Shots in Mines 151
Discussion 153, 311

HIGSON, C. H.:—
On the Walker Patent 'Indestructible' Ventilating Fan and Engines, as erected at the Park Collieries, Garswood; their construction, arrangement, and efficiency 468
Discussion 480, 578

HULL, EDWARD:—
The Earthquake Shocks of 17th August, 1892, in the British Isles, and in Central France a week later.. 197
Discussion 199

JOHNSON, ISAIAH:—
The Substitution of Steel and Iron for Timber in Mines 145
Discussion.. .. .. 147, 310

KIDSTON, ROBERT:—
Notes on Some Fossil Plants from the Lancashire Coal Measures 632

KINAHAN, G. H.:—
On the Iron Ore Measures of County Antrim 458
Bolder Clay Nodules and Ice-worn Stones.. 512
Discussion.. 516

List of Papers Read during Sessions 1891-2 and 1892-3 .. 8, 367
List of Members 33, 392
List of Officers and Council.. .. .. 11, 370
Late President, The.. 73
Library, Presentations to 8, 375
New Members..14, 45, 73, 145, 179, 235, 268, 303, 371, 443, 467, 511, 553, 577, 589
Owens College Museum Meeting 159, 487

Digitized by Google

PEILE, WILLIAM:— PAGE
Notes and Analysis of Iron Ores and Bauxite from the Crommelin Mines, County Antrim 522
PERCY, C. M.:—
Mechanical Ventilation of Mines and Walter "Indestructible" Fan.. 583
PICKUP, WILLIAM:—
Fossils from the Lower Coal Measures 237
PRESTWICH, J.:—
A Patent Miner's Safety Lamp, Lighted by Electricity.. 150
Proposed "Maskell Peace" Memorial 180
ROEDER, CHARLES:—
List of Shells from the Lower Boulder Clay at Heaton Mersey, near Manchester, with remarks thereon .. 206
SAINT, WILLIAM:—
Recent Improvements in Mining Machinery and Appliances 404
Discussion 421
STAINIER, M.:—
Temperature Observations in a Deep Coal Pit Sinking in Belgium, with an Analysis and Temperature of a Spring of Water at a depth of 3,773 feet 204
STIRRUP, MARK:—
Ordnance Survey of Great Britain, and Geological Survey of United States.. 14
Discussion 15
Discovery of a Large Boulder at Ardwick 53
Delegates' Report of the Meeting of the British Association at Edinburgh 59
Appendix to ditto 69
Collection of Fossils 142
On Some Recent Estimates of the World's Coal Supply 227
Further Notes on Boulders from the Coal Measures .. 321
Discussion 330
Report of the Delegate to the British Association Meeting at Nottingham 422
The Carboniferous Insects of Commentry, France 652

Digitized by Google

TONGE, JAMES:— PAGE
Collection of Fossils 12
On the Deepening of a Shaft at Hulton Colliery, Lancashire 216
Discussion 219

TRAQUAIR. R. H.:—
Notes on the Fossil Fish from the Marl Slate of the Trimdon Coal Company's Colliery, Durham 194

Treasurer's Balance Sheets.. .. .. 7, 366

WATTS, WILLIAM:—
Singular Nodules and Ice-Worn Stones, found in the Boulder Clay at Piethorn Valley 436
Discussion 439
Meteorological Observations of 1893, with Notes of Temperature of Moorland Streams.. 535
Discussion 543
Further Notes on Boulder Clay Nodules and Ice-Worn Stones 573
Further Notes on Meteorological Observations of 1893 575
Septarian Nodules 589

WILD, GEORGE:—
Method and Value of Fossil Collection in Coal Mining.. 222
Discussion 226

WILLIAMS, C. H.:—
Practical Notes on the Mining of Iron Ores, Bauxite, &c., of County Antrim 518

ZEILLER, R.:—
On the Fossil Plants of the Dover Coal 55

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PART XVI. VOL. XXII.

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TRANSACTIONS

OF THE

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SESSION 1893-94.

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34

CONTENTS OF PART XIX. VOL. XXII.

	PAGE.
Ordinary Meeting, April, 1894	553
New Member	553
Paper.—Mr. G. C. Greenwell, F.G.S.—On Ironstone Deposits near Dover	553
Paper.—Mr. Joseph Crankshaw.—Notes on Hurd's Patent Pneumatic Electric Coal Cutting Machine	558
Discussion	569
Paper.—Mr. William Watts, F.G.S.—Further Notes on Boulder Clay Nodules and Ice-Worn Stones	573
Paper.—Mr. William Watts, F.G.S.—Further Notes on Meteorological Observations of 1893	575

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CONTENTS OF PART XXI. VOL. XXII.

PAGE.

Ordinary Meeting, Wigan, May, 1894 577

New Members 577

The Walker Indestructible Fan. 578

Paper.—Mr. C. M. Percy.—On the Mechanical Ventilation of Mines and Walker's "Indestructible" Fan. 583

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CONTENTS OF PART XXI. VOL. XXII.

	PAGE.
Ordinary Meeting, June, 1894	589
New Members	589
Septarian Nodules	589
Paper.—Professor Boyd Dawkins, F.R.S.—On the Geology of the Isle of Man	590
Discussion	606
Paper.—Mr. Herbert Bolton, F.R.S.E.—Notes on Plant and Fish Remains from the Jarrow Colliery, Co. Kilkenny	613
Paper.—Mr. Herbert Bolton, F.R.S.E.—Note on Myriolepis Hibernica. Traq.	628
Paper.—Mr. Robert Kidston, F.R.S.E., F.G.S.—Notes on some Fossil Plants from the Lancashire Coal Measures	632
Paper.—Mr. Mark Stirrup, F.G.S.—The Carboniferous Insects of Commentry, France	652

The entire Series of the Geological Survey Maps on the one-inch and six-inch scale, with Memoirs, of the Lancashire Coal Field, is now complete, and available for reference by the Mombers.

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